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The Mammals of Mt. Kitanglad Nature Park, Mindanao Island, Philippines

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The Mammals of Mt. Kitanglad Nature Park, Mindanao, Philippines

Lawrence R. Heaney, Blas R. Tabaranza, Jr., Eric A. Rickart, Danilo S. Balete, and Nina R. Ingle

Abstract

Field surveys within and adjacent to the Mt. Kitanglad Nature Park in the Kitanglad Range of Bukidnon Province, north-central Mindanao, from 1992 to 1999, along with examination of previously existing specimens, have allowed us to document the local presence of 58 species of mammals, 53 native and five non-native. These include one gymnure (Erinaceidae), two shrews (Soricidae), one tree shrew (Tupaiidae), one flying lemur (Cynocephalidae), 14 fruit bats (Pteropodidae), eight roundleaf and horseshoe bats (Rhinolophidae), nine evening bats (Vespertilionidae), one mastiff bat (Molossidae), two primates (Tarsiidae and Cercopithecidae), three squirrels (Sciuridae), 14 mice and rats (Muridae), two civets (Viverridae), one pig (Suidae), and one deer (Cervidae). Mt. Kitanglad Nature Park has one of the most diverse mammal faunas in the Philippines, exceeding that of the more widely known Mt. Apo. Three species, a bat (*Alionycteris paucidentata*) and two native mice (*Crunomys suncoides* and *Limnomys bryophilus*), are currently known only from high elevations in the Kitanglad Range. Species richness of bats declined with increasing elevation, but richness of non-volant small mammals increased five-fold from lowlands to a peak at ca. 2250 m, and then declined with further increases in elevation. We found distinctive mammal communities in lowland rainforest (up to about 1200 m elevation), montane rainforest (ca. 1200 m to 1900 m), and mossy rainforest (2000 m to the peak at 2950 m). We conclude that all three rainforest types, at all elevations, are important to the success of the park as a biological reserve. Over-hunting of large mammals and illegal logging both pose serious problems. Lowland rainforest has been removed on much of Mindanao, including the vicinity of the park, and thus is the habitat type that is currently most threatened. Habitat destruction, especially of lowland rainforest, threatens the mammals in the Kitanglad Range as well as the economic and social stability of the human population of northern Mindanao.

Introduction

With at least 180 species of native mammals, of which minimally 115 are endemic, the Philippine Islands have one of the highest levels of endemism of any country (Balete et al., in press; Heaney et al., 1998; Rickart et al., 2002, 2003, 2005). Those countries with more endemic species are much larger; based on relative geographic area, the Philippines has one of the greatest concentrations of unique species, exceeding Brazil, Madagascar, and the nations of East Africa (Heaney & Regalado, 1998; Mittermeier et al., 1997, 2004; Ong et al., 2002). This great diversity of mammals is associated strongly with both the tropical climate and the complex geological history of the Philippines. Most of its islands are oceanic in origin, and have never been connected either to the Asian mainland or to each other (Hall, 1998, 2002; Heaney, 1985, 1986, 2004; Steppan et al., 2003), and form a mosaic of unique centers of biodiversity. Thus,

on each of the larger islands, at least 50% of the non-flying mammals occur nowhere else. Mindanao, the subject of this monograph, is the second largest island in the Philippines at 94,875 km^2. During periods of low sea level during the Pleistocene, Mindanao was connected to Leyte, Samar, Bohol, and nearby smaller islands, and thus was even larger than today, but this "ice-age island" of Greater Mindanao was never connected to any larger land mass. Of the 27 currently known species of non-flying mammals that occur naturally on Greater Mindanao, 22, or 81.5%, live nowhere else (Heaney, 1986, 2000, 2004; Heaney & Regalado, 1998; Ong et al., 2002).

Within Greater Mindanao, many mammal species are widespread, especially those that live in lowland forest, but several subcenters of endemism can also be identified. At least one species of mammal (an as-yet undescribed species of forest mouse, *Apomys*; Steppan et al., 2003) occurs only on Bohol, Leyte, and probably Samar and associated smaller islands. Three species of small mammals are restricted to Dinagat and adjacent islands (*Podogymnura aureospinula*, *Batomys russatus*, and *Crateromys australis*), and it appears that one species is restricted to the Zamboanga Peninsula (*Crocidura grandis*; Heaney, 2004, Heaney et al., 2006), though both this species and Zamboanga are poorly known. Additionally, there are many species that occur only in montane and/or mossy forest at high elevations on Mindanao; at least eight species are currently known only from such places, establishing this habitat as another subcenter of endemism. Finally, as documented here, three species (*Alionycteris paucidentata*, *Crunomys suncoides*, and *Limnomys bryophilus*) are currently known only from the Kitanglad Range, though we suspect that all three occur more widely on the many poorly known mountains of central Mindanao.

Although these basic facts of mammalian distribution have been demonstrated, much of this information has come to light only since 1992 when we began our field studies on Mindanao (which resulted in the discovery of two of the three species apparently endemic to the Kitanglad Range). Furthermore, although earlier research on Mindanao has provided a great deal of information on the distribution and ecology of some species (e.g., Hollister, 1913; Hoogstraal, 1951; Musser, 1977, 1982a,b; Rabor, 1986; Sanborn, 1952; Taylor, 1934), many species were poorly known in nearly all respects, especially those from middle and high elevations. Our field and museum-based studies have resulted in a substantial amount of new information on elevational distributions (summarized in Heaney, 2001), systematics (Rickart et al., 1998, 2003), and ecology (Ingle, 2001, 2003). We chose to focus our field studies in the Mt. Kitanglad Nature Park, one of the newer (1990) and largest (31,297 ha) of the national parks in the Philippines (Mallari et al., 2001), in Bukidnon Province of north-central Mindanao (Fig. 1). Little published information on the mammals of the park existed at the time we began our studies, though we learned that several collections had been made earlier; these are summarized here. This publication summarizes all currently available information on systematics, distribution, ecology, and conservation status of the mammals of the Kitanglad Range, in part to serve as a baseline for research in other parts of Mindanao, where mammals remain less well known.

We chose to work in the Kitanglad Range for two primary reasons. First, the Kitanglad Range includes the second-highest peak on Mindanao (2938 m) and has an extensive area at high elevation (Fig. 2). This led us to expect that we would be able to conduct a thorough assessment of the pattern of distribution and variation in mammalian assemblages along most of the elevational gradient that exists on Mindanao. Second, the Kitanglad Range supports one of the larger remaining tracts of old-growth forest on Mindanao (Environmental Science for Social Change, 2000), which we hoped would allow us to sample a region with a mammal fauna as little disturbed by humans as possible. We began our sampling at the northwest corner of the park near Barangay San Vicente, Baungon Municipality, where old-growth forest occurred in patches as low as 700 m elevation and continuous old-growth forest reached as low as 900 m elevation and perhaps lower, and proceeded to near the highest elevations in the range.

We note that photographs of live or fresh specimens and skulls of nearly all mammal species from the Kitanglad Range are available through a web site (http://www.fmnh.org/philippine_mammals/); links to pdf versions of simple, two-page field guides to non-volant mammals and to bats are also available (http://fm2.fieldmuseum.org/animalguides/).

FIG. 1. Photograph of the Kitanglad Range taken from above Silipon, below Sites 5 and 6, on 04 March 1993; Site 5 is located on the ridge in the center of the photograph.

Study Area and Methods

Geology of the Kitanglad Range

The Kitanglad Range (Fig. 2) is a part of the Central Mindanao volcanic sector, which is the largest single volcanic field in the Philippines. The sector extends from Mt. Apo in the south to Camiguin Island in the north; all of the mountains in this region have originated during the last 3 million yr, a very brief period for such extensive mountain-building (Sajona et al., 1997). The Central Mindanao volcanic sector is bounded on the east by the Philippine Fault, which runs north–south, largely beneath the Agusan River, and the Eastern Mindanao sector, which extends from Mt. Hilong-hilong in the north to Mt. Diwata in the center and the Mt. Kampalili/Mayo complex in the south. This area is geologically older, with volcanics dated to ca. 47, 46, 29, 19, 12, 11, and 3 million yr ago (Ma), as well as some that are quite recent (less than 0.25 Ma). The Central Mindanao sector is bounded on the southwest by the Cotabato Fault, which largely lies beneath the Mindanao and Alah rivers, and the Daguma/Sarangani sector, which includes the area from Mt. Talayan to Mt. Daguma and Mt. Busa, as well as the portion of the Zamboanga Peninsula to the west of Mt. Dapiak (see fig. 1 in Sajona et al., 1997). This sector also has older volcanics than Central Mindanao, with dates ranging from 32 to 6 Ma, plus Quaternary flows.

Within the Central Mindanao sector are numerous Plio-Quaternary lava flows. Beneath the lava flows are late Oligocene to early Miocene limestones overlying much-older peridolites and gabbroic/plagiogranitic formations (which probably formed deep beneath the surface). The base of the volcanic field is made up of lavas ranging from about 2.5 to 0.6 Ma. The oldest known surface flow is from Marawi (ca. 40 km west of the Kitanglad Range), dated at 2.31 ± 0.11 Ma. The Kitanglad Range and Mt. Kalatungan, immediately to the south of Kitanglad, "consist of several E–W oriented basaltic edifices … and rare andesitic/dacitic adventive domes" of Quaternary age (Sajona et al., 1997, p. 130). There are no dated flows from Kitanglad, but Mt. Kalatungan has flows dated from 0.4 ± 0.05 Ma and 0.25 ± 0.07 Ma, and volcanic material dated to 1.15 ± 0.27 Ma is known from Quezon, just southeast of Mt. Kalatungan. Other volcanics in eastern Central Mindanao range from 0.8 to 0.25 Ma (Sajona et al., 1997).

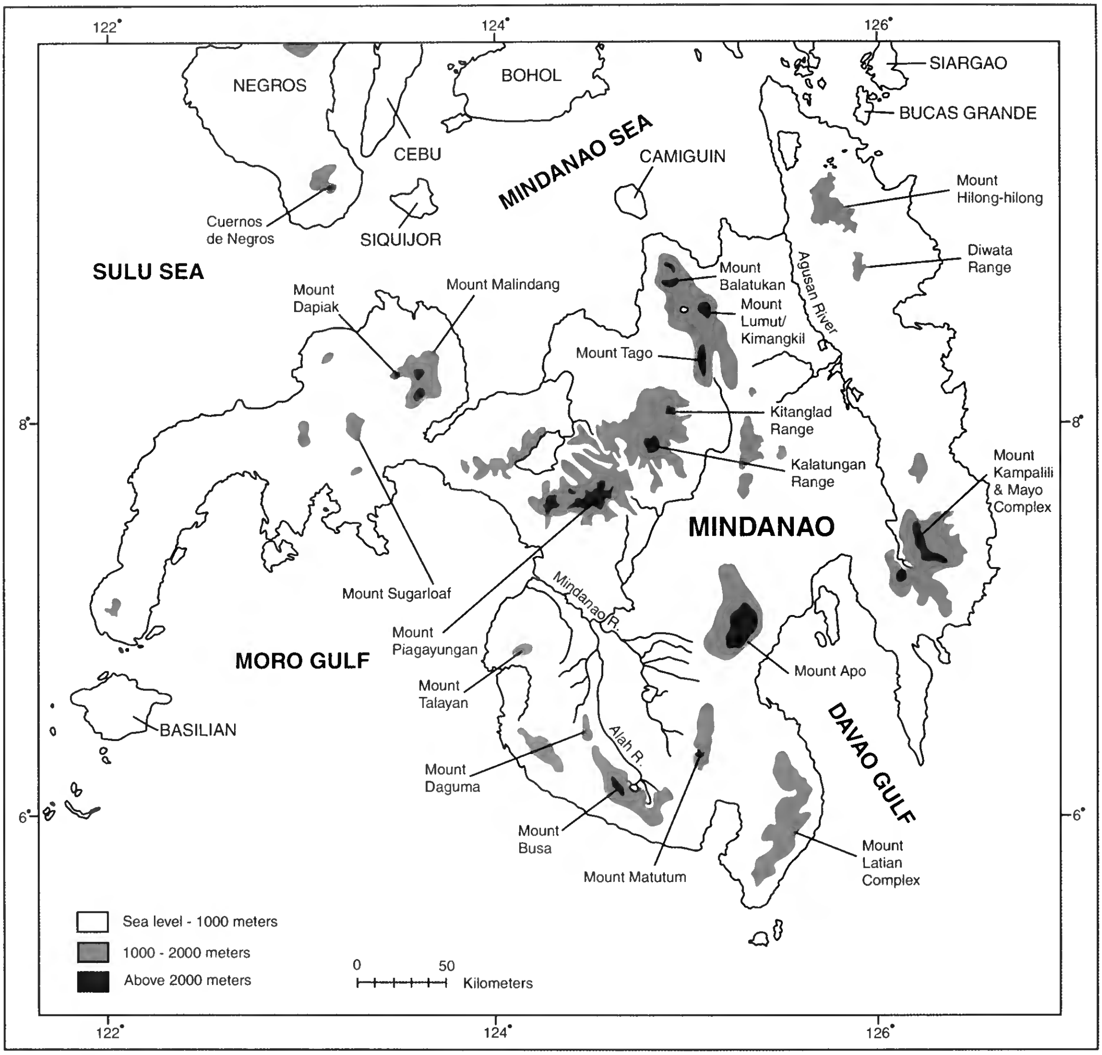

FIG. 2. Map of Mindanao Island and adjacent areas, showing major topographic features and the locations of mountains referred to in the text.

These data indicate that both the East Mindanao sector and the Daguma/Sarangani sector are substantially older than the Central Mindanao sector, and probably formed as separate islands that coalesced into a single dry-land island with the other portions of Mindanao only within the last 3 to 5 Ma as a result of volcanic activity in Central Mindanao (Hall, 2002; Hamilton, 1979; Mitchell et al., 1986; Sajona et al., 1997). Because the Kitanglad Range did not exist prior to about 400,000 yr ago, the mammals that now live there have colonized the mountain from elsewhere on Mindanao at some point(s) since then.

Climate of the Kitanglad Range

Limited data on climate are available for the Kitanglad Range, but patterns are clear. High and low temperatures taken during 2-wk periods at primary survey sites during 1992 and 1993 (Table 1) show mean highs of 25.5°C at 1100 m elevation declining to 18.1°C at 2250 m elevation, for an average lapse rate of 0.64°C per 100-m increase in elevation. Low temperatures at the same sites were 18.6°C and 11.5°C, for an average lapse rate of 0.62°C per 100-m change in elevation. These lapse rates are identical, or nearly identical, to the average lapse rate of

TABLE 1. Mean high and low temperatures recorded on the Kitanglad Range at primary survey sites during 1992 and 1993 (see Methods). n = number of days of recording. Temperatures are given as mean and range.

Site	Elevation	Dates	n	Daily highs	Daily lows
Site 2	1100 m	17–30 April 1992	14	25.5°C, 23.0–27.0°C	18.6°C, 17.5–20.0°C
Site 3	1600 m	02–21 May 1992	16	21.6°C, 19.0–24.0°C	16.1°C, 14.5–17.5°C
Site 5	1900 m	10–24 March 1993	13	19.5°C, 17.5–23.0°C	12.3°C, 11.0–13.0°C
Site 6	2250 m	18 Mar–12 Apr 1993	14	18.1°C, 16–22.5°C	11.5°C, 10.5–13.0°C

0.64°C per 100 m for moist air worldwide (Lomolino et al., 2006). With a peak elevation of 2938 m, we anticipate a temperature differential from the seashore to the peak of 18.8°C at any given point in time. Thus, on days when Cagayan de Oro experiences its mean annual daily high temperature of 27°C, the peak is likely to have high temperatures of about 8.3°C.

Because the ability of air to retain water declines as it cools, the cooling of air as it rises over the Kitanglad Range produces heavy rainfall. Average annual rainfall for Impalutao, Impasugong Municipality (600 m elevation), was 275 cm/yr (n = 11 yr); at Sumilao (700 m), 291 cm/yr (n = 9 yr); and at Chinchona (1250 m), 380 cm/yr (n = 8 yr; Manalo, 1956). Rainfall at Site 15 (1450 m) during a single year was estimated as 380 cm (Ingle, 2001). These data yield an average rate of increase in rainfall of 12.4 cm per 100 m elevation. From this rate of change, we project that rainfall should average about 480 cm/yr at 2250 m (Site 6). If the increase in rainfall were to continue to the peak at 2938 m, rainfall would be about 564 cm/yr. Similarly, rainfall would decline to about 200 cm/yr near the coast. Thus, annual rainfall on the higher portions of the mountain is very likely to be more than twice, and possibly nearly three times, that in lowland areas.

Rainfall in the Kitanglad Range is generally seasonal, with a moderately dry season generally extending from mid-November to early May, and a wet season during the other months. In Malaybalay, the driest months average more than 10 cm of rain, and the wettest average over 30 cm (Ingle, 2001). However, these averages conceal high variability from year to year, perhaps associated with the El Niño phenomenon, when rains decline dramatically, and La Niña, when rains are especially heavy.

Given the combination of declining temperature and increasing rainfall with increasing elevation, it follows that humidity is often very high on the mountain. This is consistent with our observation of increasingly abundant and frequent fog at our sites from 1600 to 2600 m elevation, and increasingly abundant epiphytes, especially moss, over this elevational range, as described below.

Methods

To make comparisons possible among sites along this transect of the Kitanglad Range and between transects on different islands, our methods followed the same procedures as used previously (Heaney et al., 1989, 1991, 1999; Rickart et al., 1993). Sampling was conducted in the lowest area of old-growth rainforest that we could locate and reach, and was then extended at sites along the elevational gradient to near the highest peaks (Fig. 3). This included sites in lowland dipterocarp forest (1100 m), montane rainforest (1600 m), transitional montane/mossy forest (1800 m), lower mossy forest (1900 m), and mossy rainforest (2250 m, 2375 m, 2600 m, and 2800 m); detailed descriptions of the sites follow. Additionally, we briefly sampled an area of partially logged lowland forest at ca. 875 m, and Ingle (2001, 2003) conducted extended studies of bats at 1450 m in regenerating montane forest. At our 10 primary sites (Sites 1–9 and 15, described below), we sampled within a ca. 50-m elevational range of the mid-point cited in the site descriptions, and within about 300 m linear distance of the central point (which typically was our camp site). At most sites, we used observation, netting, and trapping to sample the fauna, and we stayed at a given site for at least 7 days, or until we added no new species to our lists for the site.

At Sites 1–6, surveyed in 1992–1993, bats were netted in mist nets with four shelves; each net was 12 m in length. Nets were placed in locations chosen by experienced individuals as being likely to receive bat traffic, i.e., especially along ridges, but also across trails and streams, with the bottom of the net usually ranging from 0.5 m to

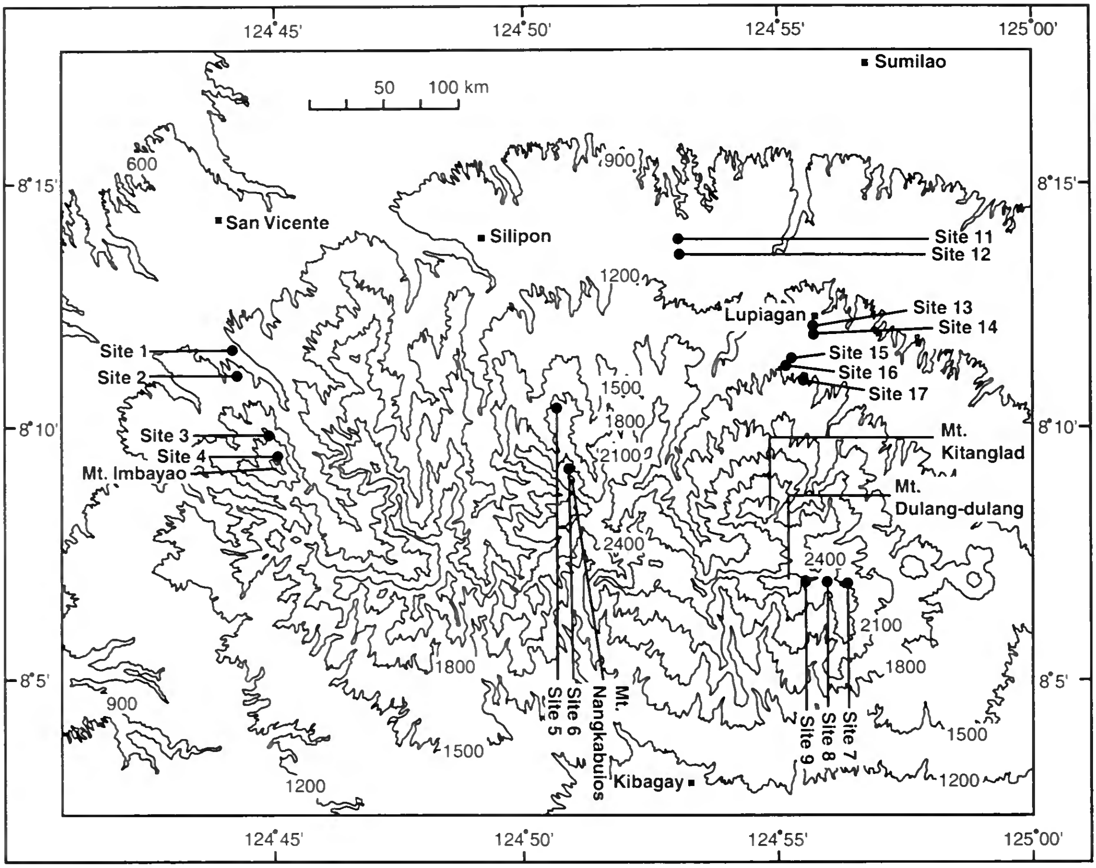

FIG. 3. Map of topographic features and collecting sites on the Kitanglad Range. Elevation is in meters.

2 m above the ground level, but at each site we set some nets 4–8 m above ground. Nets were tended continuously from early dusk until about 2100 h. Nets were left open thereafter, and bats were removed at dawn. Most nets were left in place for 3 days, then moved to a different location.

At Site 15, bats were captured in three to five net systems consisting of two to six 6-m-long nets stacked one on top of each other, with the top net up to 12 m above the ground. Nets were raised and lowered with the use of pulleys (Ingle, 1992, 1993). Between August 1998 and November 1999, netting was conducted monthly, usually for three to four nights. Nets were tended every 30 min to 2200 h, and every 1–2 h thereafter until dawn (Ingle, 2001, 2003).

At Sites 1–9, non-volant small mammals were captured in Victor rat traps (ca. 90% of traps used) and National live traps (ca. 10%). Traps were checked each morning soon after dawn (ca. 0600–0700 h), and late each afternoon (ca. 1600–1700 h). Traps were placed 3–5 m apart, with 95% set on the ground and 5% set on vines or horizontal branches, and left in place for 3 days. About 80% of the traps were set by experienced trappers. At Sites 2–6, we recorded the time when we recovered trapped animals, and used Chi-squared tests to determine diel activity patterns by calculating expected capture frequencies based on a 14-h nocturnal and/or crepuscular period, and a 10-h period of daylight. Traps were baited each morning and afternoon with either fresh, lightly roasted coconut coated with peanut butter, or with live earthworms. Only coconut bait was used in 1992 (3,047 trap-nights), but both baits were used in 1993, for 4,077 trap-nights (79%) with coconut and 1,067 trap-nights (21%) with earthworms. Bait type was rotated in a nearly random pattern among trap lines and among days within trap lines. In 1993, we recorded which bait had been used to

trap each individual, and used Chi-squared tests to determine bait preference of different species by calculating expected frequencies based on the relative effort with each type of bait.

Most small non-volant mammals collected from Site 15 and all obtained from the nearby Sites 13, 14, 16, and 17 were trapped by local people in unbaited native traps. There were four types of native traps, all made of string and either bamboo or wood. The *giman* and *latugpi* function as snap traps. The *balod* is a snare trap, and the *bayobo* is a *balod* with a low fence of stakes to funnel the animal into the trap. All trappers were Binukid-speaking residents of Barangay Lupiagan; most are members of the Higaonon ethnic group, but some were Taalandig and Bukidnon. They were asked for information on the name and habits of the animals trapped. A few specimens were taken in buildings at Site 15 with snap traps.

Voucher specimens were preserved for all species that were trapped or netted; all were cataloged and studied at the Field Museum of Natural History (FMNH), and half have been returned to the National Museum of the Philippines. Some voucher specimens from Sites 10–15 were deposited with the Park Superintendent (PASU) of Mt. Kitanglad Range Nature Park. Most specimens (ca. 95%) were preserved in formalin in the field; these were injected with an unbuffered, saturated solution of formalin, then placed in a 10% solution to which a small amount of soap had been added to allow formalin to penetrate to the skin. After several weeks, they were transferred to ethanol for permanent storage. Many of these had skulls removed and cleaned for study at FMNH. The rest were prepared as skeletons, stored in 70% ethanol in the field, then cleaned for study at FMNH. Tissue samples for genetic studies were taken from fresh specimens and frozen in liquid nitrogen.

Specimens prepared as skeletons were examined for reproductive status in the field; those preserved in formalin were examined in the museum. Embryo size was measured as crown-to-rump length (CRL). Uterine scars were detected as dark areas of pigment; in some instances, these could be assessed as being either recent or old. Nipples were recorded as enlarged (having nursed young) or small (not having nursed); in our experience with the species reported here, nipples do not fully regress after nursing. Multiparous females were defined as those showing evidence of enlarged nipples and uterine scars; females that were pregnant but had small nipples were considered primiparous. Nulliparous females were small, non-breeding individuals with small nipples and lacking uterine scars. For male specimens, we recorded testis position (abdominal or scrotal) and size (length and width).

Stomach contents were examined at FMNH from specimens in fluid. Stomachs were removed, and the contents emptied into shallow glass plates for examination under a binocular microscope.

Standard external measurements (total length, tail vertebrae, hind foot including claw, and ear) and weight (in grams) were taken in the field on fresh specimens. Cranial measurements were taken at FMNH by L. R. Heaney, using digital calipers graduated to 0.01 mm. Values in the text and tables are given as mean ± one standard deviation.

Temperatures were taken daily at 0800 h from a maximum–minimum thermometer that was attached to the side of a tree in a shaded spot; readings were rounded to the nearest half-degree centigrade.

The nomenclature of mammals used here follows Heaney et al. (1998), except that ordinal-level names follow Wilson and Reeder (2005).

Study Sites

With a maximum elevation of 2938 m, Mt. Kitanglad is the highest peak in the Kitanglad Range, and the second highest on Mindanao, following Mt. Apo (2954 m). The Kitanglad Range is generally steep and rugged, rising rapidly from a broad and relatively flat volcanic plain at ca. 900 m to several peaks in excess of 2400 m (Fig. 3). The Kitanglad Range is connected by land over 1000 m to Mt. Kalatungan and Mt. Piagayungan to the south, together comprising one of the largest upland areas on Mindanao (Fig. 2). The entire range is sometimes referred to as "Mt. Kitanglad," and specimens in museums often bear that name when they actually come from one of the associated peaks. We use the term "Mt. Kitanglad" to refer only to the peak itself (Fig. 3), and "Kitanglad" to refer to the range (including Mts. Dulang-dulang, Nangkabulos, Imbayao, and others as shown in Fig. 3).

The vegetation on the Kitanglad Range originally consisted of three primary associations. Lowland rainforest, dominated by trees of the family Dipterocarpaceae and with figs (*Ficus* spp.) commonly included, extended from the base of the range up to about 1200 m. Although some old-growth forest remains, especially at the upper edge, much has been removed and the land converted to agriculture or used for pasture, and much is covered by unproductive saw grass (*Imperata cylindrica*, locally called *cogon*). Patches of regenerating secondary lowland forest are fairly common, especially along steep hillsides near streams. In lowland forest, canopy height is usually great (often exceeding 25 m), trees have large leaves (8–15 cm length), the ground has only a thin layer of dead leaves and little or no humus, and moss is scarce. In such habitats, ants are abundant, and earthworms are usually scarce.

Beginning at about 1200 m, lowland forest is replaced over a short transition zone by montane forest, which extends to about 1900 m. This forest has very few dipterocarps or figs, but rather is dominated by oaks (often *Lithocarpus*), laurels (often *Cinnamomum*), wild cherry (*Prunus*), or oil-fruit trees (*Elaeocarpus*; Ingle, 2001). In montane forest, canopy height is usually less than 25 m, often 20 m or less, and leaves are smaller (often 5–8 cm). Climbing pandans (*Freycinetia* spp.) and climbing bamboos (*Schyzostachium* spp.) are often abundant. The ground has a continuous layer of dead leaves and humus (though these often are only a few centimeters thick), and moss grows commonly on tree trunks and logs with scattered thin patches on the ground. Ants are uncommon, and earthworms fairly common.

Beginning at about 1900 m and extending up to the peaks, the predominant vegetation is mossy forest. Here, canopy height rarely exceeds 20 m, and more often is less than 12 m. Oaks (*Lithocarpus*) and laurels (e.g., *Litsea*) are common, and conifers (Podocarpaceae), including *Dacrydium*, *Phyllocladus*, and *Podocarpus*, often are common and conspicuous because of their large girth (sometimes >1 m) and height (up to ca. 20 m). Leaves are usually small (2–4 cm). Tree ferns (*Cyathea* spp.), saxifrage (*Polysoma*), and oil-fruit trees (*Elaeocarpus*) often are abundant (Pipoly & Madulid, 1997). The ground has a thick layer of dead leaves and humus that often exceeds 1 m in depth, and moss grows on most surfaces, often forming a thick layer. *Rhododendron*, *Melastoma*, and other shrubs are often common. Ants are absent, and earthworms usually are abundant.

In all of these habitats, landslides are common because of the steep slopes and high rainfall, and natural fires occasionally occur during the dry season. As a result, there is a mosaic of older and younger successional stages, though the older ones predominate. We refer to such forest as "old-growth," rather than "primary," because the former term places less emphasis on the complete absence of any disturbance. Traditionally, nearly all of the Kitanglad Range has been used as a source of meat and medicinal plants, with trails reaching nearly every part.

As detailed below, we conducted our survey of mammals on four of the mountain peaks comprising the Kitanglad Range: Mounts Dulang-dulang, Imbayao, Kitanglad, and Nangkabulos (Fig. 3). The survey included 17 sites along elevational gradients and vegetational types from disturbed lowland forest at 825 m to old-growth mossy forest at 2800 m. The main component of our study was conducted from 1992 to 1993. Additional data were gathered in conjunction with the dissertation research of N. R. Ingle in 1996–1999. We have also included data from earlier surveys of the same area, based primarily on specimens that were deposited at the Field Museum: The Danish Philippine Expedition of 1951–1952 (Sanborn, 1953) and the Philippine Zoological Expedition of 1960 (Ripley & Rabor, 1961).

During the first year of our survey, from April to May 1992, we focused our efforts on Mt. Imbayao, at the northwestern side of the Kitanglad Range. We established four study sites at the following elevations and vegetation types: disturbed lowland forest at 825 m (Site 1), old-growth lowland forest at 1100 m (Site 2), old-growth montane forest at 1600 m (Site 3), and transitional montane/mossy forest at 1800 m (Site 4).

The following year, March to April 1993, we surveyed Mt. Nangkabulos, on the north-central portion of the range, and Mt. Dulang-dulang on the eastern front. On Mt. Nangkabulos we established two survey sites: in transitional montane/mossy forest at 1900 m (Site 5) and old-growth mossy forest at 2250 m (Site 6). On Mt. Dulang-dulang, one of us (B.R.T.) continued the survey from May to June 1993. Three sites were surveyed during this period: old-

growth mossy forest at 2300 m (Site 7), 2600 m (Site 8), and 2800 m (Site 9).

Finally, from July 1997 to November 1999, one of us (N.R.I.) conducted an extended study of seed dispersal in residual montane forest at 1450 m, on the northern flank of Mt. Kitanglad (Site 15), where she netted bats (Ingle, 2001, 2003). At the same time, she coordinated small-mammal trapping with local hunters and obtained specimens of small mammals from nearby areas, including the village of Lupiagan at 1200 m (Site 13) on the edge of residual montane forest, and three sites in similar vegetation at 1350 m to 1500 m elevation (Sites 14, 16, and 17). Several native traps were used to catch rodents (see Methods). Further, in 1996 N. R. Ingle and J. L. Sedlock made observations on a *Pteropus vampyrus* roost (Site 10), and found a skull in forest and abandoned lower mandibles from these bats in a hunter's hut at 1000 m and 1100 m, respectively (Sites 11 and 12).

The following are brief site descriptions and inclusive dates of survey:

SITE 1—Mt. Imbayao, 15 km S, 7 km E Baungon, San Vicente Municipality, 8°11.5′N, 124°44.5′E (25 April 1992). This site was in heavily disturbed lowland forest at 875 m elevation, with a mixture of slash-and-burn gardens (*kaingin*) and partially logged forest, along the Tumalaong River, one of the two headwaters of the Sumaluan River. Slopes were variable, ranging from 0–15°, most of which were in the higher range. The standing trees probably had been as tall as those at Site 2, but the bigger ones were all gone, with only the stumps, up to 1 m in diameter, remaining. Moss cover on trees was less common, but climbing pandans were just as common as at Site 2. *Piper* and *Ficus* spp. were more common here than at Site 2, as were domestic bananas (*Musa* sp.) in the clearings. We conducted limited netting of bats but no trapping at this site.

SITE 2—Mt. Imbayao, 15 km S, 6 km E Baungon, San Vicente Municipality, 8°11′N, 124°44.5′E (17–30 April 1992). This site was in old-growth lowland forest at 1100 m elevation (Fig. 4), on a narrow ridge along the northeast fork and headwaters of the Sumaluan River. Slopes on the sides of the ridge were 30–40°, but sometimes 70°. Canopy height was 20–25 m, with emergent trees reaching ca. 30 m; diameter at breast height (DBH) ranged from 25 cm to 60 cm. Canopy leaf size averaged 8–15 cm; no leaves were emarginate. Canopy vines, including climbing bamboo and pandans, and epiphytes, including orchids, ferns, and moss, were present but not common. The understory included spiny palms, rattan, saplings, and tree ferns. A thin layer of leaf litter covered most of the ground. Moss was present only on fallen logs and the bases of large trees. The soil was weathered volcanic ash, with some small stones; a thin layer of humus covered most of the ground, reaching a maximum depth of ca. 5 cm. Fallen logs were common, and large exposed rocks were present along the ridge and streams.

FIG. 4. Photograph of habitat at 1100 m (Site 2) in April 1992.

SITE 3—Mt. Imbayao, 15 km S, 7 km E Baungon, San Vicente Municipality, 1600 m elev., 8°10′N, 124°45′E (02–21 May 1992). This site was along a high ridge in old-growth montane forest (Fig. 5) with ca. 5–10° slopes on top of the ridge and about 30–60° slopes on the sides. Emergent trees, including gymnosperms (*Agathis*), had an average height of 20 m with DBH (above buttresses) of ca. 30–60 cm. The canopy trees, including some oaks (*Litho-*

FIG. 5. Photograph of lower montane rain forest at 1600 m (Site 3) in May 1992.

carpus) and laurels (*Cinnamomum*) were ca. 15 m high, with an average DBH (above buttresses) of 30 cm. Leaves averaged 5–8 cm; about half had emarginate edges. Some common epiphytes were ferns (including bird's nest ferns), orchids, and hanging moss. Canopy vines, including pandans (*Freycinetia* spp.) and rattans (*Calamus* spp.) were moderately common. Understory and ground-cover plants were dominated by ferns, saplings, a few tree ferns, erect screw-pine (*Pandanus*), and some *Melastoma* shrubs. Occasional patches of tall "saw grass" were observed. *Ficus* density was low but density of other fruiting trees was fairly high in the canopy and the understory. Density of moss was low to moderate, found mainly on tree trunks, logs, and old trees; a small amount of moss grew on the ground. The ground surface was covered by about 2–6 cm of leaf litter; this overlaid a humus layer that typically was 4–8 cm, but ranged from 2 cm to 20 cm. The humus layer was generally wet and overlaid weathered red ash. On-site disturbance consisted of a few scattered tree falls.

SITE 4—Mt. Imbayao, 15 km S, 7 km E Baungon, San Vicente, Municipality, 1800 m elev., 8°9′N, 124°45′E (10–21 May 1992). The forest at this site was old-growth transitional montane/mossy forest, near the top of a small peak. The moderately open canopy included trees that were short, ca. 15 m, on the ridge-sides, and ca. 10 m on the ridge-tops. Undergrowth was heavy, and fallen logs were common. Moss covered tree trunks, limbs, and twigs from the ground to the canopy, growing thickly on the trunks and ground but thinner elsewhere. Ferns, orchids, and other plants grew abundantly as epiphytes, and climbing pandans were abundant. Leaf litter was abundant, and the humus layer was thick (more than 1 m in most places) and spongy. A thick root mat on the surface gave the ground a springy resilience. Long strings of "Spanish moss" hung from many trees. The forest was frequently shrouded by fog.

SITE 5—Mt. Nangkabulos, 16.5 km S, 4 km E Camp Phillips, 1900 m elev., 8°10.5′N, 124°51′E (10–24 March 1993). This site lay in old-growth transitional montane/mossy forest, in an area characterized by steep slopes and fairly narrow ridge-tops. Canopy height was typically 15–20 m, but emergents (primarily a conifer with emarginate leaves, probably *Phyllocladus* sp.) reached 20–25 m; none of the trees had buttresses, DBH averaged 20–30 cm, and leaf size averaged about 20 mm in the canopy, with some up to 60 mm near the ground. Oaks and laurels were common, and a few strangler fig trees were present; dipterocarps and *Musa* appeared to be absent. Ferns and moss were the common epiphytes; "Spanish moss" and orchids were less common. Canopy vines, especially climbing pandans, were common. Fallen logs, often quite rotten, were also common. Ground cover consisted of ferns, climbing ferns, small *Melastoma* shrubs with ripe red berries, raspberry (*Rubus* sp.), and moss. Leaf litter covered virtually the entire ground surface, usually 1–2 cm deep, and was underlaid by a layer of moist humus, 10–30 cm deep, on top of weathered volcanic ash.

SITE 6—Mt. Nangkabulos, 15.5 km S, 4 km E Camp Phillips, 2250 m elev., 8°9.5′N, 124°51′E (18 March–12 April 1993). This site was located in old-growth mossy forest (Fig. 6) characterized by steep slopes, typically between 20° and 45°. The canopy was relatively open, and averaged 7–10 m in height, with emergents reaching 12–15 m on the ridge-tops and 14–18 m on the slopes. None of the trees had buttresses, and DBH

FIG. 6. Photograph of lower mossy forest at 2250 m (Site 6) on 04 April 1993. A tarp above the work table in camp is visible.

averaged 20–50 cm, but a few reached a DBH of 110 cm. The largest trees with the widest diameter were gymnosperms of at least two genera (probably *Dacrydium* and *Phyllocladus*). Leaf size in the canopy was typically 3–4 cm, with most emergent leaves only 2–3 cm; very few were emarginate. Moss, "Spanish moss," ferns, and orchids were the common epiphytes; canopy vines were nearly absent. Fallen logs were common; many were quite rotten. Understory and ground cover plants were abundant, including *Rhododendron*, fruit-bearing shrubs, saplings, ferns, and climbing ferns. Moss was common on and near the ground, 1–3 cm thick on trunks and fallen logs, but was scarce more than 2 m above the ground. Leaf litter covered virtually the entire ground to a depth of 5–20 mm, lying on top of a layer of humus 10–50 cm in thickness that overlaid weathered volcanic ash. Scattered large rocks (up to 4 m in diameter) protruded through the humus and leaves.

SITE 7—Mt. Dulang-dulang, 15 km S, 11 km W Dalwangan, Malaybalay City, 2375 m elev., 8°7.5′N, 124°56′E (26 May–04 June 1993). This site was located in old-growth mossy forest above a river and a falls bounded by very steep cliffs and vegetated slopes of about 45–70°. Moss was present, but not very common, on trunks of standing trees, fallen logs, and root tangles. A few large conifers (probably *Dacrydium* and *Phyllocladus*) were present (DBH = 100 cm) as well as many medium-sized trees (DBH = 30–60 cm). Lianas were rather common, and epiphytes were predominantly moss, orchids, and ferns. Understory plants included ferns, tree ferns, saplings, and a common plant (*Drimys piperita*) called "ali," which local people use as medicine. The ground had a moderate cover of dried leaves that lay over thick humus. A mountaineering trail traversed the area. A few scattered tree falls were noted.

SITE 8—Mt. Dulang-dulang, 15 km S, 11.5 km W Dalwangan, Malaybalay City, 2600 m elev., 8°7.5′N, 124°56′E (29 May–04 June 1993). This site was in mossy rainforest about a kilometer from Site 7. The trees on average were about 20–25 m, with trunks more profusely covered with moss than the trees of Site 7. The understory was quite dense, consisting of saplings, tree ferns, the medicinal plant *Drimys piperita*, a shrub (*Melastoma* sp.), and *Clethra canescens* (small trees with wind-dispersed seeds often common in open areas). The ridge-top was relatively broad (5–10 m) and flat, and was covered with a moderate amount of leaf litter that lay over a thick layer of humus. The mountaineering trail that traversed Site 7 also traversed this area. Some tree-falls had created openings in the canopy.

SITE 9—Mt. Dulang-dulang, 15 km S,12.5 km W Dalwangan, Malaybalay City, 2800 m elev., 8°7.5′N, 124°56′E (29 May–04 June 1993). The vegetation at this site was typical mossy forest (Fig. 7) except at the peak itself, which was elfin forest. The average height of emergent trees was about 10 m; DBH was about 20 cm but often looked larger because of the profusion of moss on trunks, branches, and twigs. Canopy leaf size ranged from 1 cm to 5 cm. Understory plants were uncommon and the ground was abundantly covered with leaf litter. The peak was characterized by sturdy but stunted trees with gnarled and twisted trunks and thickly cuticled leaves. Some grasses and a few herbaceous plants were also present. On the peak and a few meters below, mountaineers had cleared some areas in order

FIG. 7. Photograph of upper mossy forest at 2800 m (Site 9) on Mt. Dulang-dulang taken in July 1993.

to pitch tents, with minor disturbance to the vegetation.

SITE 10—Mt. Kitanglad, Manolo Fortich Municipality, 1000 m elev., (April–May 1996). This site consisted of some remnant lowland forest on a steep bank along the Mangima Creek, surrounded by grassland and agricultural areas. It is located ca. 7 km southwest of Site 15. A roost of *Pteropus vampyrus* was observed here in April and May 1996.

SITE 11—Mt. Kitanglad, 9.6 km S, 3.7 km W Sumilao Poblacion, 1000 m elev., 8°13′50″N, 124°53′10″E (1996). A *Pteropus vampyrus* skull was found in the forest at this site. It was not known if the individual had died at the site.

SITE 12—Mt. Kitanglad, Sitio Bagalangit, Barangay Kalugmanan, 9.8 km S, 3.7 km W Sumilao Poblacion, 1100 m elev., 8°13′20″N, 124°53′10″E (1996). Lower mandibles of mammals were recovered from a hunter's house located in grassland at this site. Disturbed forest remained along watercourses. It was not known where the animals had been hunted.

SITE 13—Mt. Kitanglad, Barangay Lupiagan, Sumilao Poblacion, 1200 m elev., 8°12′N, 124°55′45″E (02 March 1999, 14 June 1999). Lupiagan was a community of about 20–30 mostly wooden houses at the end of an unpaved road, surrounded by vegetable and corn farms, with remnant forest remaining along steep slopes leading down to rivers. A few specimens of small mammals were obtained from residents in this village.

SITE 14—Mt. Kitanglad, Barangay Lupiagan, 10.4 km S 3 km W Sumilao Poblacion, 1350 m elev., 8°11′50″N, 124°55′45″E (17 March 1999; 04 May 1999; 04, 21 and 23 September 1999; 15 and 16 October 1999). This site consisted of a small human settlement of at most 10 houses along Tinag-i Creek. Vegetation in the area was a mix of remnant montane forest, grassland/fernland, and subsistence agricultural plots, not unlike Site 15. Several residents supplied some rodent specimens they trapped in remnant montane forest near Tinag-i Creek.

SITE 15—Mt. Kitanglad, 10.6 km S, 2.8 km W Sumilao Poblacion, 1450 m elev., 8°11′20″N, 124°55′20″E, (July 1997 to November 1999). This was the site for N. R. Ingle's research on seed dispersal (Ingle, 2001, 2003), with bat netting conducted as part of the study; specimens of small non-volant mammals were taken or

procured opportunistically. The area was a mosaic of montane forest and successional vegetation, bordered by grassland. It was selected because of its relatively level terrain, but steep forested slopes led down to creeks. The montane forest canopy was 20–25 m high and was relatively open. Maximum DBH recorded was 65 cm. Average stem density was 650 stems/ha for stems $\geq$10 cm. Canopy trees in the genera *Lithocarpus* (oaks) and *Elaeocarpus* (oil-fruit trees) dominated the forest, comprising 32% and 22% of basal area, respectively. Other canopy trees were *Castanopsis* cf. *javanica*, *Michelia philippinensis*, *Gordonia luzonica*, and the conifer *Phyllocladus hypophyllus*. Below the canopy, *Cinnamomum* sp., *Actinodaphne diversifolia*, *Prunus grisea*, *Alstonia macrophylla*, and *Helicia* cf. *robusta* were common, occurring at densities of ca. 15 stems/ha. Erect pandans were also common. Forest floor vegetation included forest seedlings and saplings, shrubs such as *Lasianthus* spp., and, in some areas, ground ferns. *Ficus* were present but uncommon. Lianas were present but not abundant; climbing pandans were relatively abundant. An old logging road cut a 6-m wide swath through the forest. There were several areas of successional vegetation, which were inferred to be of different ages from the stature of the vegetation and its composition. *Alphitonia philippinensis*, *Mussaenda philippinensis*, *Trema* sp., and *Dodonaea angustifolia* were common in the older successional vegetation, which probably was established 20–30 yr previously. In a 1-ha abandoned slash-and-burn farm surrounded by forest and cleared about 5 yr previous to the study, common species were *Aralia bipinnata*, *Cypholophus moluccanus*, *Melastoma malabathricum*, and *Saurauia* spp. Plants were up to 5 cm diameter and up to 5 m tall. The Department of Agriculture maintained a research and demonstration farm nearby, and small-diameter timber had been collected for house construction and for firewood both in the research farm and the village, but human disturbance was at moderately low levels.

Site 16—Mt. Kitanglad, Barangay Lupiagan, 10.7 km S, 2.9 km W of Sumilao Poblacion, 1450 m elev., 8°11′10″N, 124°55′10″E (26–27 November 1999). This site was along the west side of the Miaray Creek, across from Site 15, where the vegetation was montane forest similar in composition to that of Site 15, except that there had been less disturbance because of the steep slopes.

Site 17—Mt. Kitanglad, Barangay Lupiagan, 11.5 km S, 2.2 km W of Sumilao Poblacion, 1500 m elev., 8°11′0″N, 124°55′35″E. (02 May 1999, 28 and 30 September 1999). This site was called Tawasan by the local people. It was situated in secondary forest adjacent to residual montane forest and grasslands and a vegetable farm.

Field Work by Previous Investigators

In 1960, the Peabody Museum of Yale University and Silliman University sponsored a wildlife inventory of Mt. Kitanglad headed by Prof. Rudolfo B. Gonzales (Ripley & Rabor, 1961; Rabor, 1966). The results of their mammal survey were unpublished, and we were unsuccessful in locating any field notes; some, perhaps all, of the mammal specimens were deposited at FMNH. One source of data for their sites is an article on birds (Ripley & Rabor, 1961). In that publication, however, the collection sites, their corresponding elevations, and dates of collection were not enumerated, but were mentioned in the species accounts of selected birds. The team visited the area twice that year, from April to May and during the last week of December, according to Ripley and Rabor (1961). However, dates on the FMNH specimen labels of several small mammals indicated that the team started field work during the last week of March 1960. Information about the sites enumerated below (Sites 18–20, not mapped in Fig. 3), including their elevations and the dates of collection, were based solely on data from specimen labels at FMNH. It appears that the collection of small mammals was opportunistic. Based on elevation, we surmise that the vegetation at their Site 20 approximated that of ours at Site 4, and that Site 19 was probably in old-growth rather than residual forest, perhaps similar to our Site 15.

Site 18—Mt. Kitanglad, Malaybalay City, 4200–4300 feet elev. (ca. 1300 m), (24–29 March 1960, 30 April–09 May 1960).

Site 19—Mt. Kitanglad, Malaybalay City, 5000 feet elev. (ca. 1500 m), (03–07 April 1960).

Site 20—Mt. Kitanglad, Malaybalay City, 5800–6200 feet elev. (ca. 1800 m).

In 1951–1952, an extensive survey of birds, mammals, and other wildlife was conducted on several islands by the Danish Philippine Expedition (DPE) headed by F. Salomonsen. The group

visited several areas on Mindanao, including Mt. Kitanglad, between August 1951 and March 1952. Based on the dates in published species accounts of birds and mammals (Salomonsen, 1953; Sanborn, 1953), Salomonsen and party spent at least 3 mo in Bukidnon, surveying Mt. Kitanglad and Mt. Kaatoan from October to December 1951. The party then proceeded to Agusan the following month, most likely through Cabanglasan, Bukidnon Province, where they collected a tarsier, *Tarsius syrichta*, during the first week of December.

Almost all of the specimens collected during the DPE were deposited at the Zoological Museum in Copenhagen. A few mammals, however, were deposited in the FMNH (see Species Accounts). The results of their Kitanglad sojourn, particularly regarding birds and mammals, were promptly published (Salomonsen, 1953; Sanborn, 1953). In these publications, however, the collection sites and their corresponding elevations and dates of collection were not routinely specified. Our attempt to reconstruct the Salomonsen party's collection sites and dates on the Kitanglad Range was unsuccessful because no further data were available from the Zoological Museum in Copenhagen. As with the Gonzales collection a decade later, we thus lost an opportunity to make a detailed comparison of the ensuing changes in small-mammal communities during the last four decades, a period of massive habitat destruction.

In the absence of further data, the following sites, dates, and elevations were reconstructed from available data on the labels of specimens from the DPE that are in the FMNH, as well as from relevant published accounts of birds and mammals (Salomonsen, 1953; Sanborn, 1953).

Site 21—Cabanglasan, no elev. data (December 1951). This site lies east of Malaybalay, at the border of Bukidnon and Agusan del Sur.

Site 22—Mt. Kaatoan, Cinchona, 1250 m elev., (12–23 November 1951).

Site 23—Mt. Kitanglad, 1600 m elev., (16–18 December 1951).

Site 24—Dilirig Caves, Manolo Fortich Municipality, Bukidnon (January–February 1933). Sometimes also spelled "Dalirig," this barangay is located along the boundary of the municipalities of Manolo Fortich and Sumilao, beside the primary road (formerly Highway 315, now National Road 3), about 4.5 km E Manolo Fortich poblacion at ca. 450 m. These caves are currently a tourist attraction, and were formerly heavily minded for guano. In 1933, L. H. Phillips captured *Eonycteris robusta*, *Eonycteris spelaea*, and *Hipposideros diadema*. Several specimens were deposited in the FMNH but most are in the Museum of Comparative Zoology (MCZ), Harvard University. No field notes are associated with the L. H. Phillips collection (J. Chupasko, pers. comm.).

Also deposited at the Field Museum is a specimen of *Hipposideros diadema* that Lim Boo Liat collected in 1960 from an unknown cave in Bukidnon, designated as Site 25. Unfortunately, the collectors' field notes and catalogs for both collections cannot be traced.

Site 25—Unknown cave, unknown locality in Bukidnon, unknown elevation (26 January 1960). Lim Boo Liat collected an *H. diadema* in Bukidnon, but details are absent.

Lastly, a large series of small mammals was collected in September–December 1965 by L. Bregulla and deposited at the Senckenberg Museum, Frankfurt (SMF). This collection provided the type specimen of *Alionycteris paucidentata* (Kock, 1969b). Bregulla apparently collected in several other parts of the Philippines in 1964–1966, including the Central Cordillera of Luzon, where he obtained the type specimen of *Otopteropus cartilagonodus* (Kock, 1969c). Aside from papers on *Dyacopterus spadiceus* (Kock, 1969a), and records of *Tarsomys echinatus* and *Limnomys sibuanus* (Musser, 1994), no other details on Bregulla's collecting activities on Mindanao or elsewhere in the Philippines are available in the literature. Heaney examined some specimens from this collection in June 1989, and cranial measurements of some species are included here.

Accounts of Species

Order Erinaceomorpha
Family Erinaceidae—Hedgehogs and Gymnures

Podogymnura truei Mearns, 1905

The Mindanao gymnure is endemic to Mindanao Island, where it is widespread in montane and mossy forest at 1300 m and higher; there are no historical records from lowland forest (Fig. 8; Heaney et al., 1998). The only congeneric species, *P. aureospinula*, occurs in secondary and old-growth lowland forest on Dinagat (Heaney & Rabor, 1982) and on Bucas Grande (Tabaranza, unpubl. data). During 1992 and 1993, we

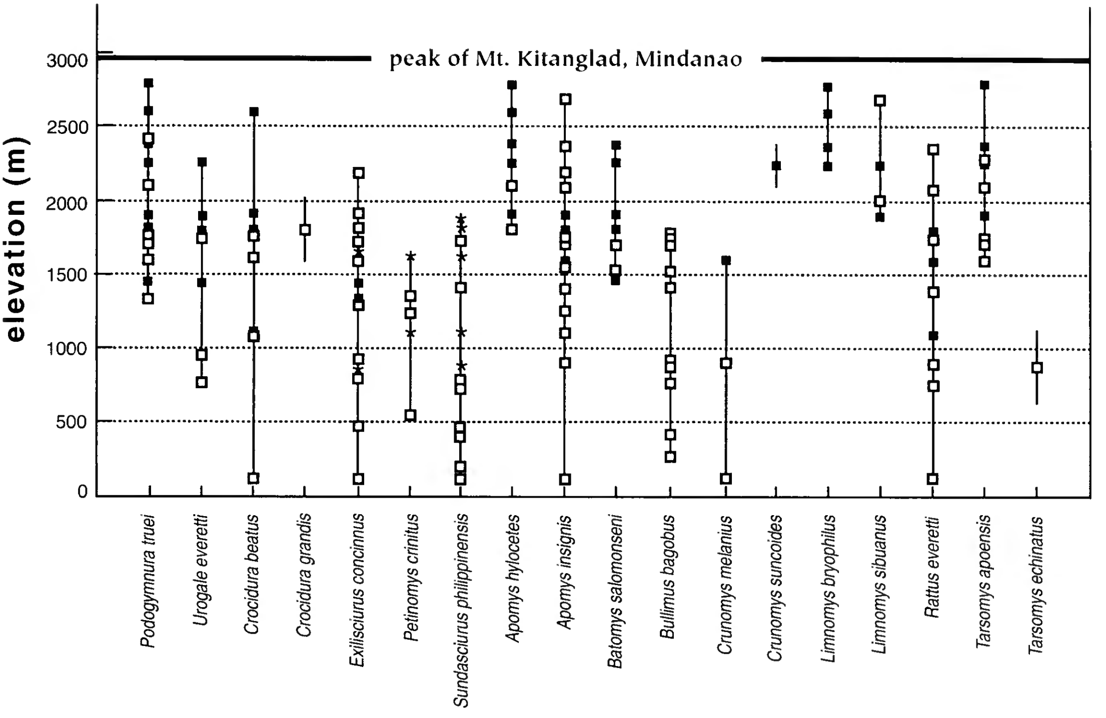

FIG. 8. Elevational ranges of small mammals from Mindanao. Records from the 1960s are indicated with open squares, and those from the 1990s by solid squares. The stars indicate documented records from the 1990s without voucher specimens (see text).

captured 94 individuals in transitional montane/mossy and mossy forest from 1800 m (Site 4) to 2800 m (Site 9); overall, it was the most common small mammal at mossy forest sites (Table 2; Fig. 8). We captured them in traps set on the ground, usually along runways, in front of holes, among mossy root tangles, under rotting fallen trees, or under the bases of standing live or dead trees. In 1999 we obtained 10 specimens trapped by local people in residual montane forest at 1450–1500 m (Site 15), using unbaited native traps called *giman* and *balod*. In December 1951, the DPE collected four individuals at 1600 m (Site 23), of which one is deposited at the FMNH (Sanborn, 1953).

In March, April, and June 1993, we captured nine pregnant females with a mean weight of 72.6 ± 9.4 g (range = 60–84 g). All but one (which had twins) had single embryos with mean CRL of 17.2 ± 14.0 mm (range = 4–40 mm, n = 9). During the same period, 18 adult females (64.6 ± 7.0 g, range = 55–78 g) had large mammae but were not pregnant and four others were nulliparous (59.5 ± 7.3 g, range = 52–68 g). None of the females captured in May 1992 (n = 13) and November 1999 (n = 2) was pregnant, but several had swollen uteri. Adult males weighed an average of 67.8 ± 6.3 g (range = 52–82 g, n = 33); young adults were slightly lighter, averaging 62.8 ± 8.5 g (range = 52–72 g, n = 5). Testis size was measured in two young adults and seven adults; size ranged from 9 × 6 mm to 14 × 7 mm. Juveniles and subadults of both sexes were recorded from March through May. There were only few of them, comprising less than 6% of the total captures in 1992, 1993, and 1999. Mean weight of the two juveniles and four subadults was 53.0 ± 6.3 g (range = 43–62 g). Of 72 standardized captures, all were recorded as nocturnal/crepuscular, and none occurred in the daytime (Table 3), indicating strongly nocturnal activity.

Earthworms were significantly more attractive as bait to *P. truei* than was toasted coconut; the only other small mammal that significantly preferred earthworms was *Tarsomys apoensis* (Table 4). Stomach contents of 55% of *P. truei* (n = 31) consisted chiefly of earthworms, crudely chewed into ca. 3-mm to 20-mm sections. In several instances, the sections were not completely severed, and portions of more than 20 mm length were found in the stomachs; one contained a ca. 50-mm earthworm that was

TABLE 2. The number of small non-volant mammals trapped at principal sites in the Kitanglad Range in 1992 and 1993. The number of standardized captures per 100 trap-nights are given in parentheses. Values in brackets include non-standardized captures; see Methods.

	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
	1100 m	**1600 m**	**1800 m**	**1900 m**	**2250 m**	**2375 m**	**2600 m**	**2800 m**
Crocidura beatus	1*	0**	1 (0.08)	1 (0.06)	0**	0**	2 (0.43)	0
Podogymnura truei	0	0	13 (1.07)	29 (1.78)	30 (1.49)	6 (0.82)	9 (1.94)	7 (2.26)
Urogale everetti	0	0	2 (0.16)	1 (0.06)	1 (0.05)	0	0	0
Apomys hylocoetes	0	0	0	8 (0.43)	58 [62] (2.83)	9 (1.23)	2 (0.43)	4 (1.29)
Apomys insignis	0	4 (0.35)	29 (2.39)	24 (1.54)	0	0	0	0
Batomys salomonseni	0	0	4 (0.33)	14 (0.86)	15 [16] (0.75)	3 (0.41)	0	0
Crunomys melanius	0	2 (0.17)	0	0	0	0	0	0
Crunomys suncoides	0	0	0	0	1 (0.05)	0	0	0
Limnomys bryophilus	0	0	0	0	16 (0.80)	1 (0.14)	4 (0.86)	5 (1.61)
Limnomys sibuanus	0	0	0	4 (0.25)	5 [6] (0.25)	0	0	0
Rattus everetti	2 (0.37)	4 (0.35)	1 (0.08)	0	0	0	0	0
Rattus exulans	0	0	0	1 (0.06)	0	0	0	0
Rattus tanezumi	0	0	0	1 (0.06)	0	0	0	0
Tarsomys apoensis	0	0	0	4 (0.25)	15 [17] (0.75)	3 (0.41)	0**	4 (1.29)
Total captures	2 [+2]	10	50 [+4]	87	140 [+8]	22	17	20
Total trap-nights	540 [+137]	1154	1216 [+172]	1626	2011 [+54]	732	465	310
Total mammals per 100 trap-nights	0.37 [0.29]	0.87	4.11 [3.89]	5.35	6.96 [7.17]	3.0	3.66	6.45
Number of species	1 + 1*	3 + 1**	6	10	8 + 1**	5 + 1**	4 + 1**	4

* caught by hand; ** presence inferred

largely intact. In these individuals, finely chewed arthropod parts were a minor element of the stomach contents. The remaining stomachs contained finely chewed arthropod parts including hymenopteran wings and coleopteran elytra. No discernable plant materials were evident in any stomach (Table 5). These data suggest that this species feeds on invertebrates, with strong tendency toward vermivory. These feeding habits are similar to those of *Chrotomys* and *Rhynchomys* from Luzon (Balete & Heaney, 1997; Heaney et al., 1998; Rickart et al., 1991).

Females are slightly larger than males in some external measurements but are very similar in most cranial measurements (Table 6). Based on a small series from Kitanglad, Sanborn (1953) described a subspecies, *Podogymnura truei minima*, that differed from the nominate form of the species from Mt. Apo in being of smaller cranial size; he used only four specimens from Mt. Apo for comparison. Direct comparison of our large series from Kitanglad with a large sample from Mt. Apo (both in FMNH) shows only a slight difference in size (Table 6); we thus agree with Corbet and Hill (1992) that recognizing two subspecies may not be justified.

Specimens from Kitanglad have a standard karyotype of 2N = 40, FN = 76 (Rickart, 2003).

SPECIMENS EXAMINED—Total 109. Site 4 (13 FMNH); Site 5 (29 FMNH); Site 6 (30 FMNH); Site 7 (6 FMNH); Site 8 (9 FMNH); Site 9 (7 FMNH); Site 15 (3 FMNH); Site 16 (5 FMNH); Site 17 (1 FMNH); Site 19 (3 FMNH); Site 20 (2 FMNH); Site 23 (1 FMNH).

TABLE 3. Diel activity patterns of small mammals on the Kitanglad Range taken in 1992 and 1993 at Sites 2–8. Diurnal activity period was 10 h, noctural/crepuscular was 14 h. Chi-squared test for expectation of activity level equal to length of diel period.

Species	Nocturnal/crepuscular		Diurnal		Total
	Observed	Expected	Observed	Expected	
Podogymnura truei	72**	41.76	0	30.24	72
Crocidura beatus	2	1.74	1	1.26	3
Urogale everetti	3	2.32	1	1.68	4
Apomys insignis	58**	33.64	0	24.36	58
Apomys hylocoetes	66**	39.44	2	28.56	68
Batomys salomonseni	33**	19.72	1	14.28	34
Crunomys melanius	2	1.16	0	0.84	2
Crunomys suncoides	1	0.58	0	0.42	1
Limnomys bryophilus	16**	9.28	0	6.72	16
Limnomys sibuanus	10**	5.80	0	4.20	10
Rattus everetti	6*	4.06	1	2.44	7
Rattus exulans	1	0.58	0	0.42	1
Rattus tanezumi	1	0.58	0	0.42	1
Tarsomys apoensis	13	12.18	8	8.82	21
Total	283**	172.84	15	125.16	298

* $p < 0.05$.
** $p < 0.01$.

Order Soricomorpha
Family Soricidae—Shrews

Crocidura beatus Miller, 1910

The Mindanao shrew is endemic to Camiguin Island and the Mindanao Faunal Region, including at least Biliran, Leyte, Maripipi, and Mindanao; it is common in primary forest particularly at higher elevations, uncommon in secondary forest, and absent outside of forest (Heaney et al., 1998, 2006). There are historical records from near sea level on Mindanao, indicating that this species originally had (and may still have) the greatest elevational range of any native mammal species on Mindanao (Fig. 8). During 1992 and 1993, we captured

TABLE 4. Bait attractiveness of roasted coconut with peanut butter vs. live earthworms at Sites 5–9 in 1993. Chi-squared test for expectation of equal trap success with the two baits, using traps set in a standardized manner, based on number of standardized trap-nights at the site(s) where the given species occurred (see Methods).

Species	Coconut		Earthworm		Total
	Observed	Expected	Observed	Expected	
Podogymnura truei	33	63.99	48**	17.01	81
Crocidura beatus	1	2.37	2	0.63	3
Apomys hylocoetes	58	62.41	21	16.59	79
Apomys insignis[1]	21	20.75	4	4.25	25
Batomys salomonseni	30*	25.28	2	6.72	32
Limnomys bryophilus	18	20.54	8	5.46	26
Limnomys sibuanus[2]	8	7.29	1	1.71	9
Tarsomys apoensis	15	20.54	11**	5.46	26
All species (all sites)	184	221.99	97**	59.01	281
1900 m, standardized trap-nights	1375 (0.83)		275 (0.17)		1626
2250 m, standardized trap-nights	1589 (0.79)		422 (0.21)		2011
2375–2800 m, standardized trap-nights	1137 (0.74)		370 (0.26)		1507
Total standardized trap-nights	4077 (0.79)		1067 (0.21)		5144

* $p < 0.05$.
** $p < 0.01$.
[1] 1900 m (Site 5) only.
[2] 1900 m and 2250 m (Sites 5 and 6) only.

TABLE 5. Stomach contents of native non-volant small mammals from the Kitanglad Range. Numerical values indicate the percent of stomachs that contained some identifiable volume of each type of material.

Species	n	Vegetable matter (seeds, etc.)	Arthropod exoskeleton	Earthworm
Podogymnura truei	31	0	100	55
Crocidura beatus	3	0	100	0
Urogale everetti	8	12	100	50
Exilisciurus concinnus	2	100	100	0
Apomys hylocoetes	40	95	100	0
Apomys insignis	35	91	97	0
Batomys salomonseni	19	100	0	0
Bullimus bagobus	3	100	100 (trace)	0
Crunomys melanius	2	100	100	0
Crunomys suncoides	1	0	100	0
Limnomys bryophilus	16	100	0	0
Limnomys sibuanus	4	100	0	0
Rattus everetti	5	100	80 (trace)	0
Tarsomys apoensis	10	100	50 (trace)	0

five individuals at sites in lowland forest at 1100 m (Site 2), transitional montane/mossy forest at 1800 m (Site 4), and mossy forest at 1900 m and 2600–2800 m (Sites 5 and 8, respectively; Table 2; Fig. 8). One of the trapped individuals was captured during the day (Table 3). Two were caught in traps baited with coconut coated with peanut butter, two in traps baited with live earthworms (Table 4), and one was hand-caught during daylight by a particularly alert field assistant. Additionally, in 1999 we found a dead shrew on the ground in residual montane forest at 1450 m (Site 15).

Stomach contents of three individuals consisted solely of finely chewed arthropod exoskeleton, including wings. These are consistent with insectivorous feeding habits. We suspect that the two individuals caught in traps baited with coconut were accidental captures, because their position in the trap suggested that they bumped the bait pedal.

Cranial and external measurements were similar in both sexes, and show only slight variation from those on Leyte, Biliran, and Maripipi (Table 7; Heaney & Ruedi, 1994; Rickart et al., 1993). Direct comparison of three adult crania from Kitanglad with specimens from Duminagat, Mt. Malindang (FMNH 87391), Dabiak, Zamboanga (FMNH 80360), and Camiguin Island (FMNH 167855) showed no evident differences. Based on a single specimen from Leyte, this species has a karyotype of 2N = 38 (Rickart, 2003).

SPECIMENS EXAMINED—Total 6. Site 2 (1 FMNH); Site 4 (1 FMNH); Site 5 (1 FMNH); Site 8 (2 FMNH); Site 15 (1 FMNH).

Suncus murinus (Linnaeus, 1766)

The Asian house shrew is a widespread commensal species recorded from Asia to Indo-Australia; it occurs throughout the Philippines, but it is not a native species. Usually it lives in urban and agricultural areas, and occasionally in disturbed forest. However, on islands with few native small mammal species, such as Camiguin and Negros, *S. murinus* is common in old-growth forest, particularly where there is natural disturbance from landslides at upper elevations (Heaney et al., 1989, 1998, 2006). In the Kitanglad Range, we found them only in association with a residential area and heavily disturbed forest, and not in primary forest (Table 1). Similar occurrence patterns were observed on Mt. Isarog, Luzon (Heaney et al., 1999) and on Biliran, Leyte, and Maripipi (Rickart et al., 1993).

In May and June 1999, we captured two males; one was caught by hand in a coffee garden close to houses in a village at 1200 m (Site 13), and the other in an unbaited native snap trap (*giman*) in residual montane forest, near the Tinag-i Creek at 1350 m (Site 14). An adult male caught on 04 May 1999 weighed 40.6 g and had scrotal testes measuring 5 × 7 mm, whereas a subadult male caught on 14 June weighed 27 g and had abdominal testes measuring 3 × 6 mm.

A Lupiagan village leader aged more than 70 yr stated that *S. murinus* had not been present

TABLE 6. Mean ± SD and range of selected external and cranial measurements of adult gymnures (Erinaceidae) and tree shrews (Tupaiidae) from the Kitanglad Range, Mindanao, Philippines. Sample size smaller than n is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	n	Total length	Tail length	Hindfoot	Ear	Weight (g)	Condylobasal length	Zygomatic breadth	Interorbital breadth	Mastoid breadth	I^1 to M^3	P^4 to M^3	M^2 to M^2 (labial)
Podogymnura	M	12	194 ± 8.5	52 ± 5.0	33 ± 1.4	21 ± 0.8	70 ± 6.3	38.2 ± 0.63	19.0 ± 0.44	9.3 ± 0.25	15.1 ± 0.43	19.4 ± 0.39	8.9 ± 0.28	10.4 ± 0.37
truei minima			179–207	43–60	30–34	20–22	62–82	37.2–39.1 (11)	18.2–19.6 (11)	9.0–9.8 (10)	14.5–15. 9 (10)	18.8–20.0	8.6–9.5	9.9–11.0
– Kitanglad	F	16	192 ± 9.6	54 ± 4.5	34 ± 1.7	21 ± 0.8	64 ± 10.0	38.2 ± 1.4	18.4 ± 0.84	9.3 ± 0.36	15.0 ± 0.69	19.4 ± 0.64	8.9 ± 0.35	10.2 ± 0.40
			177–210 (15)	48–66 (15)	31–37	20–22	43–79	35.4–40.3 (14)	16.6–20.1	8.7–10.2	13.8–16.0 (14)	18.2–20.3	8.4–9.6	9.4–10.8
Podogymnura	M	8	—	—	—	—	—	40.5 ± 1.35	20.4 ± 0.74	9.6 ± 0.36	16.2 ± 0.57	20.6 ± 0.57	9.3 ± 0.23	11.0 ± 0.28
truei truei –								38.7–42.1	19.7–21.5	8.9–9.9	15.6–17.3	19.5–21.0	8.9–9.6	10.7–11.6
Apo	F	8	—	—	—	—	—	39.7 ± 1.0	19.6 ± 0.42	9.6 ± 0.26	15.7 ± 0.42	20.3 ± 0.60	9.5 ± 0.24	10.9 ± 0.09
								38.5–41.7	19.1–20.3	9.3–9.9	15.0–16.5	19.6–21.4	9.2–10.0	10.8–11.0
Urogale everetti	M	2	337	135	49	19	223	56.2	27.1	16.5	19.5	32.4	12.5	14.7
			329–345	130–140	48–49	18–21	195–251	55.9–56.4	25.9–28.3	16.1–17.0	19.1–20.0	32.4–32.5	11.4–13.6	14.0–15.3
	F	4	331 ± 4.3	138 ± 3.5	49±1.0	18 ± 0.6	230 ± 27.1	55.1 ± 1.39	27.4 ± 0.61	16.4 ± 0.14	19.4 ± 0.41	31.6 ± 0.80	11.7 ± 0.23	15.2 ± 0.25
			325–335	136–143	48–50	17–18	210–268	53.5–56.5	26.6–27.9	16.3–16.6	18.8–19.8	30.4–32.1	11.4–11.9	15.0–15.5

TABLE 7. Mean ± SD and range of selected external and cranial measurements of adult shrews (Soricidae) from the Kitanglad Range, Mindanao, Philippines. Sample size smaller than n is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	n	Total length	Tail length	Hindfoot	Ear	Weight (g)	Condylobasal Length	Braincase width	Interorbital breadth	Rostral length	I^1 to M^3	P^4 to M^3	M^2 to M^2 (labial)
Crocidura	M	3	141	58	15	10	10	20.5	9.5	4.7	8.4	9.2	5.2	6.2
beatus			135–147	54–62	14–17	8–11	9–11	20.4–20.7	9.2–9.6	4.3–4.9	8.1–8.7	9.0–9.3	5.0–5.5	6.0–6.4
	F	4	138 (3)	57 ± 5.1	14 ± 1.8	8 (1)	10 (3)	20.5 (2)	9.4 (3)	4.8 (3)	8.1 (3)	8.7 (3)	5.0 ± 0.17	6.2 (3)
			127–148	52–63	12–16		10–11	20.4–20.6	9.3–9.6	4.5–5.1	7.7–8.4	8.3–9.1	4.8–5.2	6.1–6.2
Suncus	M	2	172	60	19	10	38	29.2	12.4	5.7	11.1	12.3	6.7	8.5
murinus			150–195	54–65	18–20	9–12	27–49	28.8–29.6	12.2–12.5	5.7–5.8	10.9–11.1	12.3–12.4	6.7	8.5–8.7

in Lupiagan (Fig. 3) when he was younger, and only arrived within the last 10 yr. The Binukid-speaking residents call this species *katiuri*.

Cranial and external measurements of two males (Table 7) fall within or slightly below the ranges of those from Camiguin (Heaney et al., 2006). Specimens from Negros Island have a karyotype of 2N = 40; FN = 60 (Rickart, 2003).

SPECIMENS EXAMINED—Total 2. Site 13 (1 FMNH). Site 14 (1 FMNH).

Order Scandentia
Family Tupaiidae—Tree Shrews

Urogale everetti (Thomas, 1892)

The Mindanao tree shrew is endemic to the Mindanao Faunal Region, on the islands of Dinagat, Mindanao, and Siargao, where it occurs in primary forest from 750 m to 2500 m (Heaney et al., 1998; Fig. 8). On the Kitanglad Range in 1992 and 1993, we captured a total of four in transitional montane/mossy forest at 1800 m (Site 4) and 1900 m (Site 5), and in old-growth mossy forest at 2250 m (Site 6; Table 2; Fig. 8). Two were caught in traps baited with coconut and peanut butter and two in traps baited with live earthworms. Three were recorded as crepuscular captures, but we suspect that they had been caught shortly before the traps were checked in early morning (Table 3). Additionally, we observed individuals on at least two occasions at the same sites as they ran from among the low branches of a tree to the ground during daytime. In 1999, 10 specimens (seven females and three males) were trapped in residual montane forest at 1450 m (Site 15), using unbaited native snare traps (*balod*) and snap traps (*giman*). In 1960, the team from Silliman University collected a single specimen in montane forest at ca. 1300 m (Site 18). The local people in the Kitanglad Range commonly call this species *talumbaboy*.

Of seven females captured in 1999, one captured in March was pregnant (268 g) with two embryos (CRL = 9 mm and 11 mm). Another female (191 g) was nulliparous. The remaining females had large mammae and swollen uteri, but were not pregnant (226 ± 24.0 g, range = 210–266 g). Adult males with a mean weight of 205 ± 31.3 g (range = 180–251 g, n = 4) had scrotal testes ranging in size from 5 × 10 mm to 6 × 12 mm. Two subadult males weighed 135 and 176 g, and one had testes measuring 3 × 6 mm.

One individual kept in captivity for 2 days in 1992 was offered a variety of food items. It readily accepted and ate a cicada, a cricket, peanut butter, cooked rice, dried mango, fresh bird entrails and the entire carcass of a small bird, a scarabid beetle, and a live skink (*Sphenomorphus*). It rejected a large (3 cm) snail, even when it was extended and moving, a saltine cracker, ants, a staghorn beetle, and two large moths. It had the strongest preference for small beetles over other choices. The stomachs of eight individuals (Table 5) all contained arthropod skeletons, and about half contained traces of earthworms, all finely chewed. The stomach of one individual contained small seeds in fruit pulp; another had bits of metallic blue coleopterans. The results of the feeding trials and stomach contents analysis suggest omnivorous feeding habits, including mostly insects, and occasionally earthworms and fruit.

Adult males and females from Kitanglad are nearly identical in most cranial and external measurements, but overall they are smaller than specimens from another part of Mindanao (Mt. Matutum, Cotabato Province) and from Dinagat and Siargao islands, indicating some geographic variation (Table 6; Heaney & Rabor, 1982).

SPECIMENS EXAMINED—Total 14. Site 4 (2 FMNH); Site 5 (1 FMNH); Site 6 (1 FMNH); Site 15 (9 FMNH); Site 18 (1 FMNH).

Order Dermoptera
Family Cynocephalidae

Cynocephalus volans (Linnaeus, 1758)

The Philippine flying lemur, called *kagwang* in several Visayan languages, is endemic to the Mindanao Faunal Region, where it is common in forest at low to middle elevations on the islands of Basilan, Biliran, Bohol, Dinagat, Leyte, Mindanao, Samar, and Siargao (Heaney et al., 1998). It is often common in heavily disturbed lowland forest, especially near slash-and-burn gardens (*kaingin*) where tall standing dead trees provide good nesting holes. On Kitanglad, we observed an individual climbing a live tree (ca. 20 cm DBH) at the edge of a *kaingin* in disturbed lowland forest at 850 m (Site 1) on 25 April 1992 at ca. 1900 h. On 12 and 23 November 1951, the DPE collected two male specimens on the Mt.

Kaatoan side of the Kitanglad Range, at 1250 m (Site 22; Sanborn, 1953).

Gestation has been estimated to last 150 days, and the young appear to be dependent on the mother for close to 200 days (Wischusen et al., 1992). On Biliran, an unweaned juvenile male was caught along with its mother in March (Rickart et al., 1993). On Mt. Apo, females were observed with young from December to June, and a record of a pregnant female in September suggests year-round reproductive activity (Wischusen et al., 1992, 1994).

Evidence of sexual dimorphism in body color, with males having darker fur, was noted in the populations on Dinagat and Siargao (Heaney & Rabor, 1982). Size variation is not pronounced among specimens from the different islands of the Mindanao Faunal Region (Heaney & Rabor, 1982; Rickart et al., 1993). A specimen from Leyte had a karyotype of 2N = 38, FN = 40 (Rickart, 2003).

SPECIMENS EXAMINED. None.

Order Chiroptera
Family Pteropodidae—Fruit Bats

Acerodon jubatus (Eschscholtz, 1831)

The golden-crowned flying fox is a Philippine endemic reported from nearly every large island in the country, with the exception of the Babuyan, Batanes, and Palawan groups. It occurs in primary and secondary forest from sea level up to 1100 m (Heaney et al., 1998). This species roosts with *Pteropus vampyrus* in mixed-species colonies formerly numbering 100,000 to 150,000 individuals; however, most colonies are now estimated at 3% to 5% of their former numbers (Heaney et al., 1998; Heaney & Heideman, 1987; Mildenstein et al., 2005; Stier & Mildenstein, 2005; Utzurrum, 1992). It is often hunted with guns, modified fish nets, and aerial fishhook lines known in Cebuano as *salabay* or *surambao* (Utzurrum, 1992). Although we received reports from local residents and farmers on Kitanglad of sightings of giant fruit bats, we neither captured nor observed them in 1992 and 1993. In 1996, N. R. Ingle and J. S. Sedlock observed a roost of giant flying foxes at Site 9 (see *P. vampyrus*), but no *A. jubatus* were positively identified. Though no specimens are available, they are likely to have been present on Kitanglad, and may still be present. Field studies focused on this species are needed.

SPECIMENS EXAMINED—None.

Alionycteris paucidentata Kock, 1969

Prior to our study, the Mindanao pygmy fruit bat was known only from a small series from an unknown site on Kitanglad (Kock, 1969b). We found this species to be most common in a habitat that is different from that of any other Philippine fruit bat: montane and, especially, mossy forest. We netted a single individual out of 530 captures in residual montane forest at 1450 m (Site 15), two in old-growth montane forest at 1600 m (Site 3), three in transitional montane/mossy forest at 1800 m (Site 4), seven in mossy forest at 1900 m (Site 5), and 27 in mossy forest at 2250 m (Site 6). At the last of these sites, it was abundant and by far the most common bat (Table 8; Fig. 9). We have no data above 2250 m that might indicate its upper limit. At all of these sites, *A. paucidentata* occurred with *Haplonycteris fischeri*, a morphologically similar fruit bat, but *H. fischeri* was most common in lowland and montane forest, and uncommon in mossy forest (Table 8). Captive *A. paucidentata* produced a chittering call similar to that of *H. fischeri*, but slightly higher in tone; we heard this call on quiet evenings in mossy forest at Site 6.

Of the 32 specimens captured from April to May 1992 and 1993, 19 were males and 13 were females. Among the females, 11 (85%) were pregnant, of which 10 were adults with enlarged nipples and one was a primiparous young adult with tiny nipples. The pregnant adults had a mean weight of 16 ± 1.1 g (n = 10, range = 15–18 g), and each had a single embryo with mean CRL of 10 ± 4.9 mm (range = 5–18 mm). The pregnant primiparous female (15 g) had a single but smaller embryo (CRL = 1.5 mm). The two non-pregnant females each weighed 15 g. Adult males weighed 15 ± 1.2 g (n = 12, range = 14–18 g) and had testis size ranging from 2 × 3 mm to 3 × 4 mm (n = 7). Young adults weighed an average of 14 g (n = 3, range = 14–15 g) and had testis size ranging from 2 × 3 mm to 3 × 4 mm (n = 2); a subadult weighed 13 g.

Adult males and females were nearly identical in most external and cranial measurements (Table 9). Rickart et al. (1999) reported a standard karyotype of 2N = 36; FN = probably 58.

SPECIMENS EXAMINED—Total 32. Site 3 (2 FMNH); Site 4 (3 FMNH); Site 5 (7 FMNH); Site 6 (19 FMNH); Site 15 (1 FMNH).

Cynopterus brachyotis (Muller, 1838)

The short-nosed fruit bat is a common species in Southeast Asia; it occurs throughout the

TABLE 8. Small fruit bats captured in the Kitanglad Range in 1992, 1993, and 1999. For each species, the total number captured (and the number of standardized captures in parentheses) is given above the number of captures per net-night (with standardized values in parentheses). Total net-nights and captures per net-night are not given for Site 15; see Methods.

Species	Site 1 825 m	Site 2 1100 m	Site 15 1450 m	Site 3 1600 m	Site 4 1800 m	Site 5 1900 m	Site 6 2250 m
Alionycteris paucidentata	0	0	1	2 (0.02)	3 (0.07)	7 (0.12)	27 (1.12)
Cynopterus brachyotis	0	31 (30) (0.29)	37	0	0	0	0
Dyacopterus sp.	0	0	1	0	0	0	0
Haplonycteris fischeri	8 (1.14)	30 (23) (0.22)	59	75 (39) (0.36)	13 (0.29)	23 (0.40)	1 (0.04)
Harpyionycteris whiteheadi	0	2 (0.02)	31	17 (6) (0.06)	2 (0.04)	*	0
Macroglossus minimus	4 (0.57)	4 (0.04)	63	14 (7) (0.06)	2 (0.04)	6 (0.11)	1 (0.04)
Megaerops wetmorei	1 (0.14)	10 (9) (0.09)	0	0	0	0	0
Ptenochirus jagori	0	4 (0.04)	194	0	0	0	0
Ptenochirus minor	4 (0.57)	21 (0.20)	136	2 (1) (0.01)	0	0	0
Rousettus amplexicaudatus	0	1 (0.01)	3	2 (1) (0.01)	0	0	0
Total captures	17	102 (94)	530**	112 (56)	20 (13)	36	29
Total species	4	8	9	6 (6)	4 (3)	3	3
Total net-nights	7	185 (103)	—	304 (107)	68 (44)	57	24
Bats/net-night	2.43	0.55 (0.91)	—	0.37 (0.52)	0.29 (0.30)	0.63	1.21

* Vocalizations heard.
** Includes five *Ptenochirus* that were not identified to species.

Philippines, where it is one of the most abundant bats in agricultural areas and disturbed forest in the lowlands from sea level to 1100 m, but is also present in old-growth lowland and montane forests on small, depauperate islands including Camiguin and Maripipi (Heaney et al., 2006; Rickart et al., 1993). On Kitanglad, it was common in old-growth lowland forest at 1100 m (Site 2) and in residual montane forest at 1450 m (Site 15), but was absent from all of our study sites in undisturbed montane and mossy forest at 1600 m and higher (Table 8; Fig. 9).

In April 1992, 11 males and 10 females were netted at Site 2. The females consisted of one young adult (34 g) and nine adults. Four lactating adults had a mean weight of 37 ± 5.7 g (range = 33–45 g), including one carrying an unweaned juvenile male. Two others were pregnant (30 g and 33 g) with single embryos (CRL = 21 mm and 2 mm, respectively). Two males were juveniles, including the unweaned one (10 g) caught together with its mother; the other weighed 16 g. Two young adult males weighed 29 g each, and seven adults had a mean weight of 32 ± 2.6 g (range = 28–36 g). On southern Negros Island, this species produces two young per year, one in March–April and another in August–September (Heideman, 1995); a similar pattern seems to be present on Kitanglad. On Mt. Makiling, Luzon, patterns of lactation indicated a birth period sometime between mid-March and mid-May (Ingle, 1992).

Males and females are similar in most external and cranial measurements (Table 9); only slight variation is evident among specimens from other islands in the Philippines, including Biliran, Catanduanes, Dinagat, Leyte, Luzon, and Maripipi (Heaney & Rabor, 1982; Heaney et al., 1991, 1999; Rickart et al., 1993). In the Philippines, this species exhibits high levels of within-population genetic variation, but low between-island differentiation (Heaney et al., 2005b; Peterson & Heaney, 1993). Similarly,

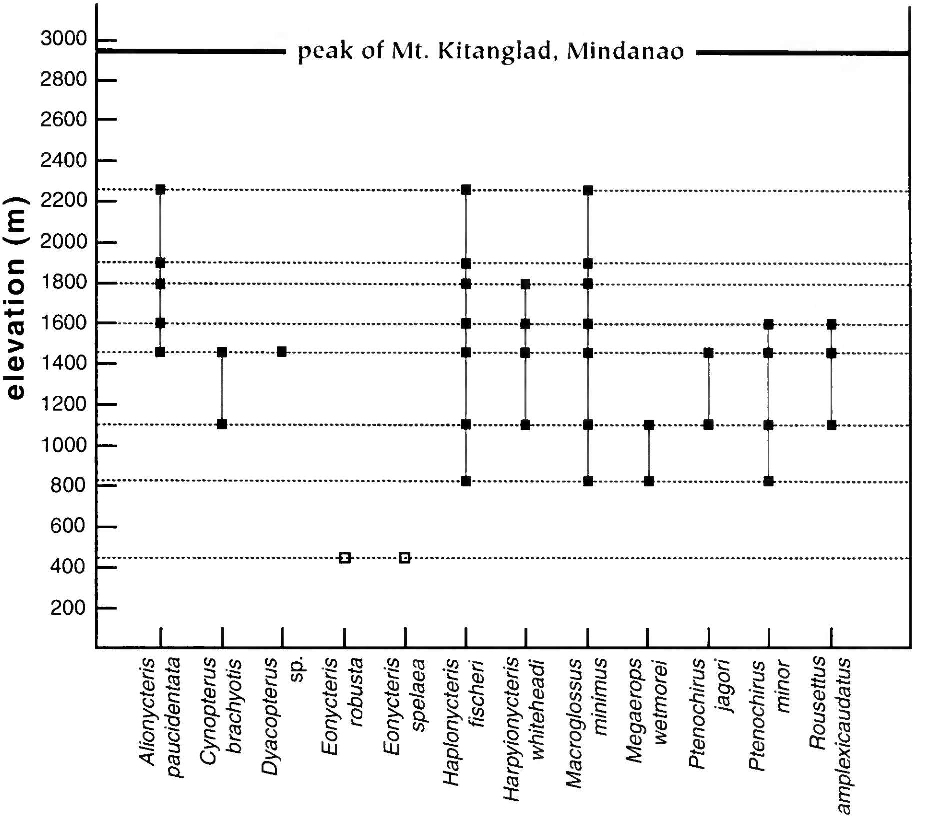

FIG. 9. Elevational ranges of fruit bats from Mindanao. Records from the 1990s are indicated by solid squares.

data from cytochrome *b*, a mitochondrial gene, indicate that two haplotype lineages are present within the Philippines, one principally on Greater Luzon and the other on Greater Negros-Panay and Greater Mindanao; however, intermixing is evident over much of the archipelago (Roberts, 2006a). Karyotypes of specimens from Leyte and Negros (2N = 34, FN = 58) are indistinguishable from those elsewhere in its geographic range (Rickart et al., 1989).

Recent molecular studies have shown that *C. brachyotis*, as currently defined, is not monophyletic, and it is clear that taxonomic changes are needed (Campbell et al., 2004; Kitchener & Maharadatunkamsi, 1991; Roberts, 2006a). Some of the molecular evidence indicates that two species are present on Borneo that have been lumped together as *C. brachyotis*, and that Philippine populations are more closely related to one of these (the "Sunda form") than to the other (the "Forest form"; Campbell et al., 2004). Most Philippine populations may eventually be referred to the name currently used as a subspecies (*C. b. luzoniensis*), but many details remain to be determined. Much additional study is needed to assess the implications for taxonomy and biogeography of these bats.

SPECIMENS EXAMINED—Total 21. Site 2 (21 FMNH).

Dyacopterus sp.

The genus *Dyacopterus* occurs from Sumatra to the Malay Peninsula and the Philippines, where it was previously known from only two specimens, one from Abra Province, Luzon (Kock, 1969a), and the other from Misamis Oriental Province, Mindanao (Heaney et al., 1998). A nulliparous young adult female (148 g) was netted in residual montane forest at 1450 m (Site 15) on 29 November 1998 (Fig. 9). The occurrence of *Dyacopterus* on the two largest Philippine islands, and in two faunal regions, suggests that it could be widely distributed. In Malaysia (where they roost in hollow trees and caves), *Dyacopterus spadiceus* was thought to be rare before it was discovered that it could be

TABLE 9. Mean ± SD and range of selected external and cranial measurements of adult fruit bats (Pteropodidae) from Mount Kitanglad, Mindanao, Philippines. Sample size smaller than n is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	n	Total length	Tail length	Hind foot	Ear	Forearm	Weight (g)	Condylobasal length	Zygomatic breadth	Interorbital width	Mastoid breadth	Rostral length	C^1 to last M	Molarifom tooth row
Alionycteris	M	16	70 ± 2.1	0	12 ± 0.7	14 ± 0.6	46 ± 1.8	15 ± 1.2	21.7 ± 0.52	14.0 ± 0.33	4.8 ± 0.20	10.3 ± 0.30	7.1 ± 0.28	7.1 ± 0.23	4.8 ± 0.15
paucidentata			66–72 (12)	0	11–13 (12)	13–15 (12)	44–50	14–18 (12)	21.2–23.3 (15)	13.7–14.8	4.5–5.2	9.6–10.8 (15)	6.7–7.6	6.8–7.6	4.5–5.1
	F	8	70 ± 2.1	0	12 ± 0.5	14 ± 0.5	48 ± 1.2	16 ± 1.3	21.7 ± 0.24	13.9 ± 0.39	4.8 ± 0.32	10.2 ± 0.19	7.2 ± 0.21	7.1 ± 0.14	4.8 ± 0.13
			68–72 (7)	0	11–12 (7)	14–15 (7)	46–49	15–18 (7)	21.2–22.0 (7)	13.1–14.2	4.2–5.2	10.0–10.4	6.9–7.5	7.0–7.3	4.6–5.0
Cynopterus	M	6	96 ± 5.4	7 ± 2.5	15 ± 0.5	18 ± 0.5	63 ± 2.0	31 ± 3.1	27.9 ± 0.74	18.4 ± 0.67	6.1 ± 0.38	11.9 ± 0.29	8.7 ± 0.42	9.4 ± 0.26	6.6 ± 0.17
brachyotis			89–102	3–10	15–16	18–19	61–66	28–36	27.0–28.9	17.4–19.3	5.8–6.6	11.6–12.2	8.1–9.3	9.0–9.7	6.4–6.9
	F	7	103 ± 4.5	8 ± 2.0	16 ± 0.7	18 ± 0.9	64 ± 1.7	35 ± 4.5	27.8 ± 0.39	19.0 ± 0.57	6.0 ± 0.28	12.0 ± 0.32	8.6 ± 0.26	9.4 ± 0.18	6.6 ± 0.17
			97–107	5–10	15–17	17–20	61–66	32–45	27.3–28.4	18.2–19.7	5.7–6.6	11.6–12.4	8.3–9.0	9.0–9.6	6.3–6.8
Dyacopterus sp.	F	1	162	18	25	21	92	148	40.5	28.8	9.2	16.6	12.6	14.5	10.0
Eonycteris robusta	M	1	—	—	—	—	—	—	36.8	23.1	7.6	15.6	14.6	14.1	10.1
	F	1	—	—	—	—	—	—	33.5	20.4	6.9	13.6	13.3	12.2	8.9
Haplonycteris fischeri	M	16	74 ± 2.3	0	12 ± 0.7	13 ± 0.7	48 ± 1.6	19 ± 1.3	23.7 ± 0.62	16.0 ± 0.59	5.7 ± 0.28	10.8 ± 0.23	7.4 ± 0.30	8.3 ± 0.31	5.8 ± 0.24
			69–78 (11)	0 (11)	12–14 (11)	12–14 (11)	46–51 (11)	16–21 (11)	22.6–24.4	14.9–16.8 (15)	5.3–6.2	10.4–11.2 (15)	7.0–8.0	7.8–9.0	5.5–6.4
	F	11	74 ± 2.3	0	13 ± 0.8	14 ± 0.5	50 ± 1.4	19 ± 1.2	23.7 ± 0.67	15.9 ± 0.40	5.7 ± 0.30	10.6 ± 0.26	7.4 ± 0.28	8.1 ± 0.27	5.6 ± 0.22
			70–78 (9)	0	12–14 (9)	13–14 (9)	47–52 (9)	17–21 (8)	22.0–24.5	15.2–16.6 (10)	5.2–6.1	10.2–10.9	6.9–7.8	7.6–8.5	5.5–6.0
Harpyionycteris	M	6	145 ± 3.2	0	22 ± 1.5	22 ± 0.8	86 ± 2.9	110 ± 7.4	41.2 ± 1.15	23.6 ± 0.65	6.6 ± 0.24	15.4 ± 0.52	11.2 ± 0.62	15.9 ± 0.50	12.1 ± 0.45
whiteheadi			140–148		21–25	21–23	82–89	99–120	40.1–42.9	23.0–24.8	5.9–6.6	14.4–15.9	10.6–11.8	15.0–16.5	11.5–12.6
	F	6	147 ± 3.3	0	23 ± 1.1	23 ± 0.7	85 ± 2.8	115 ± 12.2	41.4 ± 0.94	23.9 ± 0.83	6.4 ± 0.47	15.4 ± 0.37	11.1 ± 0.31	15.8 ± 0.24	11.9 ± 0.28
			143–152		22–25 (5)	22–24 (5)	83–90 (5)	105–135 (5)	40.0–42.6	22.8–25.2	5.7–7.0	14.9–15.9	10.8–11.6	15.5–16.1	11.5–12.2
Macroglossus	M	7	70 ± 2.2	0	13 ± 0.8	16 ± 0.4	42 ± 1.0	16 ± 2.3	24.6 ± 0.47	14.6 ± 0.20	4.6 ± 0.26	10.1 ± 0.20	9.2 ± 0.22	8.3 ± 0.15	5.1 ± 0.32
minimus			67–73		12–14	16–17	40–43	11–18	24.0–25.2	14.3–14.8	4.2–4.9	9.8–10.4	8.9–9.5	8.1–8.5	4.5–5.4
	F	5	68 ± 2.3	0	13 ± 0.8	16 ± 0.9	43 ± 0.9	15 ± 1.3	24.5 ± 0.40	13.4 ± 0.50	4.6 ± 0.28	10.1 ± 0.20	9.0 ± 0.28	8.4 ± 0.14	5.0 ± 0.23
			66–72		12–14	15–17	42–44	14–17	23.8–24.8	12.8–14.0	4.3–5.0	9.9–10.4	8.9–9.6	8.2–8.6	4.7–5.3
Megaerops wetmorei	M	7	77 ± 3.2	4 ± 0.8	12 ± 0.5	14 ± 0.5	50 ± 1.0	18 ± 1.8	22.7 ± 0.93	15.2 ± 0.41	4.9 ± 0.20	10.1 ± 0.25	7.1 ± 0.36	7.3 ± 0.16	5.1 ± 0.16
			74–81 (4)	3–5 (4)	12–13 (4)	14–15 (4)	47–51	16–20 (4)	21.6–24.1	14.6–15.8	4.6–5.2	9.7–10.3	6.7–7.7	7.2–7.6	4.8–5.3
	F	3	78	4	12	14	52	20	22.5	15.0	4.8	10.0	7.0	7.5	5.2
			76–79 (2)	3–5 (2)	12 (2)	13–14 (2)	51–52	19–21 (2)	22.3–22.7	14.6–15.3	4.7–5.0	10.0–10.1	6.8–7.3	7.3–7.7	5.1–5.4
Ptenochirus jagori	M	4	133	11	22	23	84	87	35.3 ± 0.86	24.8 ± 0.38	6.9 ± 0.26	14.9 ± 0.39	10.4 ± 0.35	12.4 ± 0.37	8.8 ± 0.42
			130–136 (3)	9–12 (3)	22 (3)	22–24 (3)	82–85 (3)	82–92 (3)	34.3–36.1	24.4–25.3	6.5–7.0	14.5–15.4	10.1–10.9	11.9–12.7	8.2–9.1
Ptenochirus minor	M	8	116 ± 3.8	10 ± 1.9	18 ± 0.8	20 ± 1.0	75 ± 1.1	55 ± 3.5	31.6 ± 0.35	21.3 ± 0.87	6.3 ± 0.28	13.3 ± 0.26	9.8 ± 0.28	11.0 ± 0.41	7.7 ± 0.26
			111–122 (7)	8–12 (7)	18–20 (7)	19–21 (7)	74–77 (7)	52–62 (7)	31.1–32.1	19.8–22.7	5.8–6.7	12.8–13.6	9.5–10.3	10.5–11.5	7.3–8.1
	F	7	119 ± 5.4	9 ± 1.7	19 ± 1.1	21 ± 1.1	76 ± 2.2	61 ± 7.8	31.9 ± 0.50	21.0 ± 0.65	6.6 ± 0.30	13.3 ± 0.40	9.8 ± 0.44	11.0 ± 0.21	7.7 ± 0.19
			112–125	7–12	17–20	19–22	73–78	51–70	31.2–32.6	20.2–21.8	6.1–7.0	12.8–13.9	9.1–10.4	10.7–11.3	7.5–8.0
Pteropus vampyrus	M	1	—	—	—	—	—	—	75.7	43.1	10.1	23.9	26.8	30.3	20.1
Rousettus	F	2	139	15	20	20	82	66	35.2	20.9	7.6	13.0	12.8	12.8	9.5
amplexicaudatus			135–143	15	19–21	20–21	82–83	60–73	34.6–35.9	20.8–21.0	7.6	12.7–13.2	12.8–12.9	12.6–13.0	9.4–9.6

commonly captured in high nets (Francis, 1990; Payne et al., 1985). Our specimen was netted about 4 m above the ground. Although it was not caught in other nets we set reaching up to 12 m above ground, further use of raised nets in different parts of the country may result in new records.

External and cranial measurements (Table 9) fall within the range of the previous two specimens in the country (Ingle & Heaney, 1992). Our data are consistent with the observation of Corbet and Hill (1992) that the Philippine specimens, along with those from Sumatra, are larger than the nominate form from Borneo, Peninsular Malaysia, and Thailand, and may be distinct; detailed study is under way (K. Helgen, pers. comm.).

SPECIMENS EXAMINED—Total 1. Site 15 (1 FMNH).

Eonycteris robusta Miller, 1913

The Philippine nectar bat is an endemic species, recorded on most large islands except in the Babuyan, Batanes, and Palawan groups of islands. It has been captured in caves and adjacent forest, and in both primary and mixed forest and clearings, from sea level up to ca. 1100 m. Although the ecology of this species is poorly understood, its association with caves and adjacent forest in the lowlands suggests the importance of both habitat features in roosting and foraging (Heaney et al., 1998). Though apparently common in the 1960s, it is now encountered less frequently, perhaps because of the same heavy hunting pressure and disturbance of caves that have plagued the more widespread *E. spelaea* (Heaney et al., 1998, Rickart et al., 1993; Utzurrum, 1992). On Kitanglad in 1992–1999, we failed to capture any; further netting in the remaining forest patches at 1000 m and below is needed to determine if the species is absent. Two adult males from caves in Dilirig at ca. 450 m (Site 24), collected in January–February 1933, comprise the only record of this species in Bukidnon Province.

Cranial measurements (Table 9) are similar to those from Biliran, Dinagat, Leyte, and Maripipi (Heaney & Rabor, 1982; Rickart et al., 1993) but slightly larger than those from Catanduanes and mainland Luzon (Heaney & Rabor, 1982; Heaney et al., 1991). Specimens from Catanduanes Island have a karyotype of 2N = 36, FN = probably 66, similar to *E. spelaea* (Rickart et al., 1989, 1999).

SPECIMENS EXAMINED— Total 2. Site 24 (2 FMNH).

Eonycteris spelaea (Dobson, 1871)

The common nectar bat occurs from India to Timor and throughout the Philippines, where it is common in agricultural areas from sea level to 1100 m, roosting only in caves (Heaney et al., 1998). No specimens were captured during the present survey. Our record of this species in Bukidnon consists of three specimens collected in January–February in the Dilirig Caves (Site 24), where the specimens of *E. robusta* also were taken.

No information on its habitat in Bukidnon is available. Like *E. robusta*, it is closely associated with caves, many of which are now seriously disturbed or degraded by hunting, tourism, and mining for guano (Rickart et al., 1993; Utzurrum, 1992). Since the 1990s, it has been captured in low numbers in parts of its former range, e.g., Catanduanes, Luzon (Mt. Makiling, Mt. Isarog, and Sierra Madre), and Maripipi (Danielsen et al., 1994; Heaney et al, 1991, 1999; Ingle, 1992). The species has a standard karyotype of 2N = 36, FN = 66 (Rickart et al., 1989).

SPECIMENS EXAMINED: Total 3. Site 24 (3 MCZ).

Haplonycteris fischeri Lawrence, 1939

The Philippine pygmy fruit bat is endemic but widespread throughout the country, excluding Camiguin Island, Sibuyan, and the Batanes, Babuyan, and Palawan groups of islands; a population that occurs on Sibuyan may represent a distinct species (Heaney et al., 1998). It occurs in primary and secondary forest up to 2250 m, most commonly at middle elevations (Heaney et al., 1998). On the Kitanglad Range, it was about equally common at our 1100, 1600, 1800, and 1900 m sites, but because most other bats declined with increasing elevation, it was proportionately more common at the upper end of this range (Table 6). At 2250 m (Site 6), it was quite uncommon; this is the site at which *Alionycteris paucidentata* was abundant. At our site in residual montane forest at 1450 m (Site 15), *H. fischeri* was the fourth most commonly captured fruit bat species (Table 8; Fig. 9).

In April to May 1992, we recorded 19 pregnant females, of which nine were multiparous and 10 were primiparous. Multiparous females were slightly heavier at 20 ± 1.8 g (range 17–23 g) than the primiparous ones at 18 ± 0.7 g (range = 17.5–20 g). Two multiparous females were in more advanced pregnancy (each carrying

one embryo with CRL of 13 and 21 mm, respectively) than the other seven, which had embryos with a mean CRL of 3.3 ± 0.5 mm (range = 2.5–4.0 mm). The primiparous females, on the other hand, had uniformly small embryos (CRL = 2.9 ± 1.0 mm, range = 1.5–5 mm). During the same period, testes of adult males ranged in size from 2 × 3 mm to 5 × 6 mm (n = 13). Lactating females were netted in October 1998 and October 1999. Elsewhere in its range, Ingle (1992) recorded pregnant females in late May and early June and lactating ones in July on Mt. Makiling, Luzon Island. Delayed embryonic development of up to 8 mo after implantation was documented in *H. fischeri* on Negros Island by Heideman (1989). This delayed development extends to 11.5 months the gestation period of this species, making it the longest known among bats. The delay has a further effect of synchronizing the reproductive cycles of females in local populations of this species.

Males and females from the Kitanglad Range differ only slightly in most external and cranial measurements (Table 9). Measurements of Kitanglad specimens are nearly indistinguishable from those of specimens from other parts of the species range, including Biliran, Catanduanes, Leyte, and southern Luzon (Mt. Isarog), in most external and cranial measurements (Heaney & Rabor, 1982; Heaney et al., 1991, 1999; Rickart et al., 1993). However, there is extensive between-population genetic variability and differentiation in this species across islands defined by Pleistocene sea levels (Heaney et al., 2005b; Peterson & Heaney, 1993). Moreover, Roberts (2006b) found that DNA sequences of the cytochrome *b* gene from populations from Kitanglad and Apo differ substantially from populations from Lake Sebu, South Cotabato Province, and from Leyte and Biliran islands, as well as from outside of the Greater Mindanao Faunal Region; clearly, additional study is needed. Specimens from Biliran and Leyte islands have a standard karyotype of 2N = 58; FN = 66, the highest diploid number so far documented (Rickart et al., 1989).

SPECIMENS EXAMINED—Total 79. Site 1 (8 FMNH); Site 2 (19 FMNH); Site 3 (27 FMNH); Site 4 (3 FMNH); Site 5 (20 FMNH); Site 6 (1 FMNH); Site 15 (1 FMNH).

Harpyionycteris whiteheadi Thomas, 1896

The harpy fruit bat, a Philippine endemic, is found throughout the country except the Batanes/Babuyan and Palawan groups of islands (Heaney et al., 1998). It is typically absent outside forest, uncommon in old-growth lowland forest, and moderately common in mid- to high-elevation old-growth forests up to 1800 m, where it appears to specialize in feeding on both the flowers and fruits of climbing pandans, *Freycinetia* spp. (Heaney et al., 1998, 2006). On the Kitanglad Range (Fig. 9), it was moderately common in old-growth lowland forest at 1100 m (Site 2), in primary montane forest at 1600 m elevation (Site 3), and in transitional montane/mossy forest at 1800 m (Site 4; Table 8). We heard their distinctive whistling call at night in primary mossy forest at 1900 m (Site 5). A total of 31 individuals was captured in residual montane forest at 1450 m (Site 15), representing 6% of all fruit bat captures at that site. In November 1951, the DPE collected a female specimen at 1250 m on Mt. Kaatoan (Site 22). The Binukid-speaking people on the Kitanglad Range call this bat *sabul*.

In April and May 1992, we captured nine females at Sites 2 and 3, of which seven were pregnant. Two nulliparous females each weighed 105 g, whereas the pregnant ones had a mean weight of 126 ± 15.2 g (n = 5, range = 115–140 g). Pregnant females had single embryos with a mean CRL of 28.6 ± 11.5 mm (n = 7, range = 15–45 mm). Nine males captured during this period were adults, with a mean weight of 110 ± 7.0 g (n = 8, range = 99–120 g) and testis size ranging from 6 × 9 mm to 8 × 12 mm (n = 5).

Among adult specimens from Kitanglad, males and females were similar in most external and cranial measurements (Table 9). On Leyte, however, males were slightly larger than females (Rickart et al., 1993). There is little variation in external and cranial measurements between Kitanglad specimens and those from Luzon (Mt. Isarog), Camiguin, and Leyte (Heaney, 1984; Heaney et al., 1999, 2006; Rickart et al., 1993).

The standard karyotype of *H. whiteheadi*—2N = 36, FN = 58 is distinctive in having several pairs of relatively large acrocentrics and in the absence of small acrocentrics; the former elements ally it with the cynopterine section of the subfamily Pteropodinae and the latter differentiate it from the same—highlighting its uncertain phylogenetic relationship with the rest of the Philippine Pteropodinae (Rickart et al., 1989).

SPECIMENS EXAMINED—Total 18. Site 2 (2 FMNH); Site 3 (16 FMNH).

Macroglossus minimus (E. Geoffroy,1810)

The dagger-toothed flower bat ranges from Thailand to Australia and throughout the Philippines. It is often abundant in agricultural areas, and less common in secondary and old-growth forests, over a broad elevational range (Heaney et al., 1998, 2005a). On the Kitanglad Range, we netted 31 individuals in 1992 and 1993 from disturbed lowland forest at 825 m (Site 1) up to the old-growth mossy forest site at 2250 m (Site 6), usually in association with wild banana (*Musa* spp.; Fig. 9). It was most common in disturbed lowland forest at 825 m (Site 1). In residual montane forest at 1450 m (Site 15), 63 individuals of *M. minimus* were captured, representing 12% of all fruit bats captured at that site (Table 8, Fig. 9).

Of those captured at Sites 1–6, 12 were females, consisting of a single juvenile (11 g), two subadults (13 g each), three adults (mean = 16 g, range = 14–17 g), and six young adults (14 ± 0.5 g, range = 14–15 g). Three primiparous females caught in May had single embryos (CRL mean = 6.3 mm, range = 5–8 mm). At sites 1-6, 17 males included two juveniles (11 g and 12 g), two subadults (12 g each), one young adult (13 g), and 12 adults (mean weight of 16 ± 0.9 g, range = 15–18 g). Juvenile males were captured only in March. Testis size among the adult males ranged from 2.5 × 2.5 mm to 7 × 9 mm (n = 9). On Negros Island, Heideman and Utzurrum (2003) found seasonal synchrony in birth periods, with two seasons per year, but within a season, births occurred over a broad period; females then undergo postpartum estrus (Heideman, 1987).

Adult males are slightly larger than females in most external and cranial measurements (Table 9). In most measurements, Kitanglad specimens are similar to those from elsewhere on Mindanao (Lanao Province), Dinagat, and Luzon (Mt. Isarog), and cluster around the mid- to lower measurement ranges of specimens from Biliran, Camiguin, Catanduanes, Leyte, and Maripipi (Heaney, 1984; Heaney & Rabor, 1982; Heaney et al., 1999, 2006; Rickart et al., 1993). Data from DNA sequence studies of cytochrome *b*, a mitochondrial gene, shows three primary lineage groups, one of which is associated with Greater Mindanao, another with the central Philippines (including Leyte, Greater Negros-Panay, Sibuyan, and the Bicol Peninsula of southern Luzon), and the third with central and northern Luzon; however, there is intermixing of haplotypes throughout the archipelago. This suggests that moderate levels of gene flow, but some clear geographic structuring of populations, are present (Roberts, 2006a). The species has a standard karyotype of 2N = 34, FN = 62 (Rickart et al., 1989).

SPECIMENS EXAMINED—Total 30. Site 1 (4 FMNH); Site 2 (4 FMNH); Site 3 (12 FMNH); Site 4 (2 FMNH); Site 5 (6 FMNH); Site 6 (1 FMNH); Site 15 (1 FMNH).

Megaerops wetmorei Taylor, 1934

The Mindanao white-collared fruit bat ranges from Borneo to peninsular Malaysia and Mindanao Island; on Mindanao, it is confined largely to old-growth forest or disturbed areas at the fringes of forests (Heaney et al., 1998). In April 1992, we netted one individual in disturbed lowland forest at 850 m (Site 1) and 10 in old-growth lowland forest at 1100 m (Site 2; Table 8, Fig. 9). Five females in this sample included two young adults (16 g and 17 g) and three adults averaging 21 g (range = 17–24 g). All adult females and one young adult (16 g) were pregnant, each with a single embryo (CRL = 3–29 mm). Three young adult males averaged 16 g (range = 16–17 g), and three adults averaged 19 g (range = 17–20 g). Testes of two adult males were 4 × 4 mm and 5 × 6 mm, and a young adult had testes measuring 3 × 5 mm.

Adult males and females are of very similar size in most external and cranial measurements (Table 9). Based on the limited external and cranial measurements presented for the Borneo specimens (Payne et al., 1985), those from Kitanglad are larger. Conspicuous neck tufts present in Bornean representatives of this species are either absent or poorly developed in Philippine specimens (Corbet & Hill, 1992).

SPECIMENS EXAMINED—Total 11. Site 1 (1 FMNH); Site 2 (10 FMNH).

Ptenochirus jagori (Peters, 1861)

A Philippine endemic, the musky fruit bat occurs throughout the country, except in the Batanes/Babuyan and Palawan groups of islands. It is usually abundant in old-growth lowland forest, common in secondary forest, and uncommon at higher elevations and in heavily disturbed forest and agricultural areas (Heaney et al., 1989, 1998, 1999, 2006). In 1992, we netted a few of this species in old-growth lowland

forest at 1100 m (Site 2; Fig. 9). In residual montane forest at 1450 m (Site 15), *P. jagori* was the most commonly netted species, represented by 37% of all fruit bats netted (Table 8).

At Site 2, we captured a young adult (89 g) and three adults with an average weight of 84 g (range = 82–92 g). A study on Negros Island revealed that females give birth to a single young, with two birthing seasons, in late March or early April and in August (Heideman & Powell, 1998). The same study documented a post-implantation delay in early development, previously known to occur in two Philippine endemic pygmy fruit bats, *Haplonycteris fischeri* and *Otopteropus cartilagonodus* (Heideman, 1989; Heideman et al., 1993). However, in *P. jagori* the delay is shorter, up to 5 mo, and occurred only in primiparous females. As a result, young females give birth only once in their first year, and are in synchrony with the second birth period of older adult females (Heideman & Powell, 1998).

From early January to early December 1999 at Site 15, N. R. Ingle monitored a *Ptenochirus* day roost in an abaca (*Musa textilis*) plant. Up to three bats roosted under leaves about 5 m above the ground. The number of individuals in the roost varied from none to three from day to day. A nylon cloth cone attached to a circular wooden frame was put underneath the roost to collect falling fruits, seeds, and other matter dropped by the bats. Most of the materials that fell into this trap were pieces of *Ficus* fruits from which the juice had been extracted. The few large seeds that were observed under the day roost came from such locally common tree genera as *Elaeocarpus*, *Eugenia*, and *Prunus*. Unfortunately, we were unable to ascertain the specific identity of the roosting individuals because of the difficulty in distinguishing *P. jagori* from its congener *Ptenochirus minor*, which was also present at the site.

The primary external difference between the two species of *Ptenochirus* is overall size; *P. jagori* is larger than *P. minor*. Forearm length, especially when taken with calipers to increase precision and accuracy, can allow distinction of most adults (Ingle & Heaney, 1992). For *Ptenochirus* netted on Kitanglad at 1450 m, forearm measurements of adult *P. minor* ranged from 70.9 mm to 78.9 mm (n = 69), and those of *P. jagori* from 79.4 mm to 91.7 mm (n = 63). These ranges do not overlap but come very close, and are likely to overlap if measurements are taken by different people. Furthermore, volant juveniles of *P. jagori* had forearm lengths down to 76.6 mm, well within the range for *P. minor*. We measured the width across the bases of the upper canines (C^1–C^1) with plastic calipers on live animals, and found that C^1–C^1 on juveniles and adults was 6.2–7.5 mm for *P. minor* (n = 72), and 7.6–8.9 mm for *P. jagori* (n = 111), with only one *P. jagori* with C^1–C^1 = 7.6 mm. We therefore recommend measuring both forearm length and C^1–C^1 on live *Ptenochirus* spp. using calipers to increase the certainty of correct identification in the field.

Our small sample of crania from Kitanglad (all males, n = 4; Table 9) show little variation from those elsewhere (Heaney 1984; Heaney & Rabor, 1982; Heaney et al., 1991, 1999, 2006; Rickart et al., 1993). Adult males are slightly larger than females (Heaney et al. 1999; Rickart et al., 1993). Studies of DNA sequence data from cytochrome *b*, a mitochondrial gene, indicate four primary lineage groups: one of which is primarily associated with Greater Luzon and Greater Negros-Panay, two that occur throughout the archipelago, and one that is associated primarily with Greater Mindanao, though all are widespread; high levels of gene flow are implied (Roberts, 2006a). The standard karyotype of *P. jagori* is 2N = 44, FN = 56 (Rickart et al., 1989).

SPECIMENS EXAMINED—Total 6. Site 2 (4 FMNH); Site 15 (1 FMNH, 1 PASU).

Ptenochirus minor Yoshiyuki, 1979

The lesser musky fruit bat is endemic to the Mindanao Faunal Region, with confirmed records from Biliran, Dinagat, Leyte, and Mindanao. Earlier studies found them to be common in old-growth forest, especially at lower elevations, uncommon in secondary or degraded forest, and only rarely found outside of forest (Heaney et al., 1998). On the Kitanglad Range, this species was common in disturbed lowland forest at 825 m (Site 1) and old-growth lowland forest at 1100 m (Site 2), uncommon in old-growth montane forest at 1600 m (Site 3), and absent from transitional montane/mossy and mossy forest (Table 8, Fig. 9). In residual montane forest at 1450 m (Site 15), this species was the second most frequently netted species after *P. jagori*, comprising 26% of all fruit bats.

From April to May 1992, our captures consisted of 13 females and 13 males, of which only five were young adults; no juveniles or subadults were captured. Among 11 adult females with enlarged nipples, seven were pregnant (mean = 64 ± 5.1 g, range = 55–70 g).

Each had a single embryo (mean CRL = 35 ± 4.7 mm, range = 28–41 mm). Two primiparous females (50–51 g) each had a single embryo (CRL = 2–3 mm). Among males, 10 adults had a mean weight of 55 ± 3.4 g (range = 50–62 g), whereas the three young adults averaged 54 g (range = 53–55 g). Testis size among the adults ranged from 5 × 6 mm to 8 × 9 mm (n = 6). One young adult had testis size of 4.5 × 5 mm.

In most external and cranial measurements, Kitanglad specimens are indistinguishable from those on Dinagat and slightly larger than those from Biliran and Leyte (Table 9; Heaney & Rabor, 1982; Rickart et al., 1993). However, cranial differences between adult males and females from Kitanglad are not as pronounced as those for specimens from Biliran and Leyte (Rickart et al., 1993). The standard karyotype of *P. minor*, 2N = 46, FN = 56 (?), is similar to that of *P. jagori*, differing mainly in the number of subtelocentric and acrocentric pair complements in the autosomes, but also differing in its higher diploid number (Rickart et al., 1989).

Externally, the two species of *Ptenochirus* are similar (Yoshiyuki, 1979). As noted for *P. jagori*, on live individuals, measurement of the width across the upper canines (C^1–C^1), coupled with that of forearm length, allows distinction between the two species. A Binukid-speaking resident of Lupiagan said the local name is *tagbungan*. It is possible that *P. jagori* and other species of fruit bats are also included under this name.

SPECIMENS EXAMINED—Total 28. Site 1 (4 FMNH); Site 2 (21 FMNH); Site 3 (2 FMNH); Site 15 (1 FMNH).

Pteropus vampyrus (Linnaeus, 1758)

The giant flying fox ranges from Indochina to Lesser Sunda Islands and throughout the Philippines, except the Babuyan and Batanes group of islands (Heaney et al., 1998). A specimen from Kaatoan at 1250 m (Site 22) was reported by Sanborn (1953). On the Kitanglad Range, none were netted at any of our sites, which was not surprising because they usually fly above the forest canopy. However, from the field house situated in residual montane forest at 1450 m (Site 15), N. R. Ingle observed about 500 flying foxes flying in from the northwest at dusk on several nights in November 1998. In late December 1998, substantially fewer individuals were observed at the same site, and none were seen by early January. According to local people the appearance of these flying foxes in their area is seasonal, and occurs when the anii tree (*Erythrina* sp.) is flowering.

In May 1996, in Barangay Kalugmanan, Manolo Fortich, at 800 m elevation, we observed flying foxes feeding in flowering *Erythrina* trees. The bats probably came from the only roost reported in the area, which N. R. Ingle and J. Sedlock observed with telescope and binoculars in April 1996. The roost was located in residual forest on a steep bank along the Mangima Creek, at ca. 1000 m (Site 10). About 1,700 individuals were counted roosting in 13 trees. *Pteropus vampyrus* was positively identified; it was not determined whether *Acerodon jubatus*, which often roosts in association with former, was also present. On two occasions, one afternoon and one morning, we observed the roost being shot at by a hunter, which caused the bats to leave their roosting trees and settle in a different group of trees. A skull was found in nearby forest (Site 11), and lower mandibles were recovered in a hunter's house (Site 12). These are strong indications that this species was being exploited for food by some local people on the Kitanglad Range, as were several non-volant mammals (NORDECO & DENR, 1998).

SPECIMENS EXAMINED—Total 9. Site 11 (1 [cranium only], FMNH); Site 12 (8 [lower mandibles only], FMNH).

Rousettus amplexicaudatus (E. Geoffroy, 1810)

The common rousette ranges from Thailand to the Solomon Islands and throughout the Philippines, where it is uncommon in forests but increases in abundance in association with disturbed habitat and agricultural areas; they roost only in caves (Heaney et al., 1998). At our forested sites on the Kitanglad Range, we recorded only a few, one in old-growth lowland forest at 1100 m (Site 2), three (of 530 captures) in residual montane forest at 1450 m (Site 15), and two in old-growth montane forest at 1600 m (Site 3; Table 8; Fig. 9). In April and May 1992, we netted three adult females at Sites 2 and 3 that weighed an average of 67 g (range = 60–73 g), each with a single embryo (CRL = 9–12 mm). Elsewhere in the Philippines, lactating females were recorded in May on Mt. Makiling, Luzon Island (Ingle, 1992). Pregnancies were noted on Negros Island from December through June, with a peak in February, and on Biliran, Leyte, and Maripipi from early March to early July. Similar to *P. jagori*, the

TABLE 10. Insectivorous bats captured on the Kitanglad Range in 1992, 1993, and 1999.

	Site 1	Site 2	Site 15	Site 3	Site 4	Site 5	Site 6
Species	825 m	1100 m	1450 m	1600 m	1800 m	1900 m	2250 m
Coelops hirsutus	1[1]	0	0	0	0	0	0
Hipposideros obscurus	0	6	0	0	0	0	0
Rhinolophus arcuatus "small"	0	0	0	19	0	0	0
Rhinolophus arcuatus "large"	0	0	1	0	0	0	0
Rhinolophus inops	0	9	3	0[2]	0[2]	7	3
Rhinolophus virgo	0	1	0	0	0	0	0
Kerivoula hardwickii "large"	0	0	0	2	0	0	0
Kerivoula hardwickii "small"	0	0	1	0	0	0	0
Miniopterus australis	0	0	1	0	0	0	0
Miniopterus schreibersii	0	1	0	0	0	0	0
Murina cyclotis	0	2	0	0	0	0	0
Myotis sp.	0	1	0	0	0	0	0
Philetor brachypterus	1	0	0	0	0	0	0
Pipistrellus javanicus "small"	0	2	4	2	0[2]	1	15
Pipistrellus javanicus "large"	0	3	1?	0[2]	1	1	0
Pipistrellus tenuis	0	0	0	0	0	1	0
Otomops sp.	0	0	1	0	0	0	0
Total captures	1+1[1]	24	22	23	1	8	18
Total species	1+1[1]	8	6	3(+2)[3]	1(+2)[3]	4	2
Total net-nights	7	185	—	304	68	57	24
Bats/net-night	0.14	0.13	—	0.08	0.02	0.14	0.75

[1] Caught by hand.
[2] Presence inferred.
[3] Total documented (plus number inferred).

species was recorded to give birth twice each year on Negros, the first in March to April and the second in July through early September (Heideman, 1987; Heideman & Utzurrum, 2003; Rickart et al., 1993).

External and cranial measurements of two Kitanglad specimens (Table 9) fall within the range of those from the islands of Biliran, Catanduanes, Leyte, and Maripipi, but cluster close to the lower ranges of the specimens from Davao Province, Mindanao, and the islands of Siargao and Samal (Heaney & Rabor, 1982; Heaney et al., 1991; Rickart et al., 1993). The species has a karyotype of 2N = 36, FN = 68 (Rickart et al., 1989).

SPECIMENS EXAMINED—Total 3. Site 2 (1 FMNH); Site 3 (2 FMNH).

Family Rhinolophidae

Coelops hirsutus (Miller, 1910)

The Philippine tailless roundleaf bat is a poorly known species endemic to the Philippines, with verified records only from Mindoro (the holotype) and the specimen reported here from Mindanao (Heaney et al., 1998). An adult male was brought to us by local people; it was caught inside a shallow cave, ca. 12 m high × 20 m deep, along Tumalaong River, close to our site in disturbed lowland forest at 825 m (Site 1; Table 10). Other, larger bats were present but were not captured.

This species was described based on a skin preserved in alcohol; the carcass had been lost by the time of description, and has not been found subsequently (N. Woodman, pers. comm.). The forearm length given for the holotype (33.8 mm) is similar to that of our specimen (35 mm). In his description of the holotype, Miller (1910) mentioned a tail measuring 7 mm; our specimen, like all other specimens of *Coelops*, lacks a tail (Corbet & Hill, 1992). According to N. Woodman (pers. comm.), who examined the holotype in October 2004, and verified by one of us (L.R.H.) in January 2005, no tail bones or tail

sheath are present, though the humeri and femurs are all still present. We think it likely that Miller (1910) erred in reporting a tail. However, the uropatagium is narrow and is torn where a tail would be, if present, leaving some ambiguity.

Cranial measurements of our specimen (Table 11) are similar to those of *Coelops robinsoni* from Borneo and the Malay Peninsula (Lekagul & McNeely, 1977; Payne et al., 1985), which some authors (e.g., Corbet & Hill, 1992), consider to be conspecific with *C. hirsutus*. We tentatively retain *C. hirsutus* as a distinct species until more specimens are available for study.

SPECIMENS EXAMINED—Total 1. Site 1 (1 FMNH).

Hipposideros diadema (E. Geoffroy, 1813)

The diadem roundleaf bat is distributed from Burma to the Solomon Islands and the Philippines, where it is absent only from the Babuyan and Batanes groups of islands. In the Philippines, it typically occurs in primary to very heavily disturbed lowland forest and shrubby agricultural areas, from sea level up to 900 m, with roosting sites inside caves, tree hollows, and man-made tunnels (Esselstyn et al., 2004; Heaney et al., 1998, 1999; Rickart et al., 1993; Sedlock, 2001). We did not record it on the Kitanglad Range during our surveys in 1992–1993 and 1998–1999. However, 20 specimens from Bukidnon were collected at 450 m in Dilirig Caves in January–February 1933 (along with *Eonycteris robusta* and *E. spelaea*); two are deposited at the Field Museum and the rest are at the MCZ, Harvard (J. Chupasko, pers. comm.). Another specimen at the Field Museum, an adult male from an unspecified limestone cave, also in Bukidnon, was collected by Lim Boo Liat on 26 January 1960.

The few records of reproduction in the Philippines indicate that pregnancies occur in March on Leyte, March and May on Luzon (Mt. Isarog), and May on Palawan, with females having single embryos (Esselstyn et al., 2004; Heaney et al., 1999; Rickart et al., 1993).

Males are typically slightly larger than females (Ingle & Heaney, 1992). External and cranial measurements of Bukidnon specimens (Table 11) are similar to those for specimens from Catanduanes, Leyte, and Luzon (Heaney et al., 1991, 1999; Rickart et al., 1993), but geographic variation has not been adequately assessed. Sedlock (2001) has described the echolocation call on Luzon. Specimens from Leyte Island had standard karyotypes of 2N = 32, FN = 60 (Rickart et al., 1999).

SPECIMENS EXAMINED—Total 3. Site 24 (2 FMNH); Site 25 (1 FMNH).

Hipposideros obscurus (Peters, 1861)

The Philippine forest roundleaf bat is endemic to the Philippines (absent from the Palawan and Batanes/Babuyan island groups), where it occurs in primary and disturbed lowland forest up to 850 m. It has been found in caves and other roosting places with dark cavities including mine shafts, culverts, tree hollows, and tree buttresses (Heaney et al., 1998, 1999; Sedlock, 2001).

On the Kitanglad Range in April 1992, we netted six specimens in primary lowland forest at 1100 m (Site 2; Table 10); this elevation is higher than previously recorded for the species, and is because of the elevated position of habitats on Kitanglad (see Discussion). Three adult females with enlarged nipples, each weighing 12 g, were pregnant, each with a single embryo (CRL = 20–21 mm). One nulliparous female weighed 10 g. An adult male had testis size of 4 × 5 mm. In other parts of its range, pregnant females were recorded from the third week of April on Maripipi, and the last week of July on Mt. Makiling, Luzon Island (Ingle, 1992; Rickart et al., 1993).

Adult males are larger than females in most external and cranial measurements (Heaney et al., 1991; Rickart et al., 1993; Table 11). Overall, direct comparison showed the Kitanglad specimens were slightly smaller than one from Catanduanes (FMNH 142349). A specimen from Conel, Mindanao (FMNH 56689), previously referred to this species (Sanborn, 1952) is still smaller and has a shorter braincase and smaller nasal swellings. Published measurements of specimens from Dinagat, Maripipi, and Luzon (Mt. Isarog) (Heaney & Rabor, 1982; Heaney et al., 1991, 1999; Rickart et al., 1993) are slightly smaller as well. More specimens and an assessment of geographic variation are needed. Sedlock (2001) has described the echolocation call on Luzon. Specimens of *H. obscurus* from Catanduanes and Negros islands had a karyotype of 2N = 24, FN = 44, representing one of the lowest diploid numbers known among rhinolophids (Rickart et al., 1999).

SPECIMENS EXAMINED—Total 6. Site 2 (6 FMNH).

TABLE 11. Mean ± SD and range of selected external and cranial measurements of adult horse-shoe and leaf-nosed bats (Rhinolophidae) from the Kitanglad Range, Mindanao, Philippines. Sample size smaller than n is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	n	Total length	Tail length	Hindfoot	Ear	Forearm	Weight (g)	Condylobasal length	Zygomatic breadth	Interorbital width	Mastoid breadth	Rostral length	C^1 to last M	Molariform tooth row
Coelops hirsutus	M	1	40	0	9	14	35	—	12.9	6.4	1.7	6.7	2.3	4.3	3.5
Hipposideros diadema	M	2	—	—	—	—	—	—	28.0	17.9	3.4	14.8	6.9	11.3	8.5
									27.4–28.6	17.5–18.3	3.4	14.7–15.0	6.6–7.1	11.3	8.0–9.0
Hipposideros	M	2	81	24	12	20	46	10	16.3	10.9	2.3	9.7	3.3	6.5	5.5
obscurus			81	24–25	11–13	20–21	45–46	10	16.2–16.4	10.8–11.0	2.1–2.5	9.6–9.7	3.2–3.4	6.4–6.6	5.5
	F	4	78	21	12	20	46	12	16.4 ± 0.25	10.9 ± 0.26	2.7 ± 0.09	9.5 ± 0.13	3.1	6.5 ± 0.23	5.1 ± 0.09
			78 (2)	21 (2)	12 (2)	20–21 (2)	46 (2)	12 (2)	16.2–16.7	10.7–11.2	2.6–2.8	9.4–9.7	3.0–3.2(2)	6.2–6.7	5.0–5.2
Rhinolophus arcuatus	M	9	70 ± 2.9	19 ± 2.7	11 ± 0.5	20 ± 0.5	43 ± 1.0	8 ± 0.5	17.7 ± 0.23	9.1 ± 0.23	1.6 ± 0.09	9.0 ± 0.12	4.4 ± 0.22	6.8 ± 0.14	5.0 ± 0.14
"small"			65–74	14–23	10–12	19–21	42–45	8–9	17.4–18.0 (8)	8.8–9.5	1.5–1.7	8.8–9.2	4.0–4.7	6.6–7.1	4.8–5.2
Rhinolophus arcuatus "large"	M	1	69	15	11	19	46.3	8.7	18.8	9.3	1.7	9.4	4.7	7.3	5.4
Rhinolophus inops	M	5	86 ± 2.8	23 ± 3.3	14 ± 1.1	25 ± 0.8	54 ± 0.4	16 ± 0.4	22.4 ± 0.44	11.7 ± 0.12	2.1 ± 0.22	11.0 ± 0.09	5.6 ± 0.19	8.9 ± 0.20	6.6 ± 0.10
			83–89	19–27	13–16	24–26	54–55	16–17	21.8–22.9	11.5–11.8	1.9–2.5	10.9–11.1	5.4–5.8	8.6–9.1	6.5–6.7
	F	5	83 ± 4.7	21 ± 2.6	15 ± 1.9	25 ± 0.5	55 ± 1.3	16 ± 2.2	22.1 ± 0.49	11.6 ± 0.23	2.0 ± 0.12	10.8 ± 0.21	5.6 ± 0.26	8.8 ± 0.25	6.5 ± 0.09
			76–89	18–24	13–18	25–26	54–57	14–18	21.5–22.6	11.4–12.0	1.8–2.1	10.6–11.1	5.2–5.8	8.5–9.1	6.4–6.6
Rinolophus macrotis	M	1	—	—	—	—	—	—	18.6	8.9	2.4	9.6	8.0	6.6	4.9
	undetermined	1	—	—	—	—	—	—	—	9.0	2.3	9.4	—	6.7	5.1
Rhinolophus virgo	M	1	73	23	8	19	38	6	16.0	8.7	2.2	8.6	3.9	6.4	4.9
	undetermined	1	—	—	—	—	—	—	15.1	8.3	2.3	8.0	—	5.7	4.7

Rhinolophus arcuatus Peters, 1871

The arcuate horseshoe bat occurs from Sumatra to New Guinea and throughout the Philippines, including the Palawan Faunal Region (Esselstyn et al., 2004; Heaney, 1999). Ingle and Heaney (1992) noted two morphotypes of this species in the Philippines: one slightly smaller, with a narrower anterior noseleaf, typically found in lowland caves or disturbed habitats, and the other slightly larger, with a proportionately wider anterior noseleaf, usually found in upland forest, designated as *R. arcuatus*–small and *R. arcuatus*–large, respectively, with some variation between islands within both morphs. These forms represent a species complex that requires extensive study.

On the Kitanglad Range, we netted 19 individuals in old-growth montane forest at 1600 m (Site 3) and one in residual montane forest at 1450 m (Site 15; Table 10). The specimens from Site 3 are the small morph; the one from Site 15 is the large morph (Table 11). Direct comparison with a series of five from Tegato, Mindanao (FMNH 61229–61233; Sanborn, 1952), showed these to be the large morph as well.

Previously recorded in agricultural to primary forest in lowland and montane forest up to 1400 m (Esselstyn et al., 2004; Heaney et al., 1999; Sedlock, 2001), the Kitanglad records in montane forest at 1600 m extend the elevational upper limit of the species complex, due to the elevated position of habitat types on Kitanglad (see Discussion). A Binukid-speaking resident of Lupiagan gave the local name as *tambulalang*. It is possible that this name refers to all species of *Rhinolophus*.

All 20 individuals we netted were adults, consisting of 19 males and one female. Conspicuous sign of reproductive activity was absent. Pregnancies were recorded in March on Luzon (Mt. Isarog), in April on Biliran, Leyte, and Maripipi, and in May on Camiguin and Palawan (Esselstyn et al., 2004; Heaney et al., 1999, 2006; Rickart et al., 1993). Specimens from Biliran Island (small morph) and Luzon Island (large morph) had similar standard karyotypes of 2N = 58, FN = 60 (Rickart et al., 1999). Sedlock (2001) has described the echolocation call on Luzon.

SPECIMENS EXAMINED—Total 20. Site 3 (19 FMNH; small morph); Site 15 (1 FMNH; large morph).

Rhinolophus inops K. Andersen, 1905

The Philippine forest horseshoe bat is endemic to the Philippines, occurring on most of the larger islands of the Luzon, Mindanao, Mindoro, and Negros-Panay faunal regions. It is often common to abundant in primary lowland and montane forest from sea level up to 2250 m, and less common in secondary lowland and mossy forest (Heaney et al., 1998, 1999, 2006; Rickart et al., 1993; Sedlock, 2001).

On the Kitanglad Range in 1992–1993, this bat was fairly common in old-growth lowland forest from 1100 m (Site 2) to mossy forest at 1900 m (Site 5) and 2250 m (Site 6; Table 10). In 1998–1999, three were netted in residual montane forest at 1450 m (Site 15).

We captured seven adult females, of which three were pregnant (two in March and one in September). The pregnant females averaged 17 g (range = 15–18 g); two had single embryos with a CRL of 20 mm each. Non-pregnant females weighed 15 ± 2.0 g (range = 14–18 g). Adult males had a mean weight of 17 ± 0.9 g (n = 12, range = 16–19 g), whereas a single young adult weighed 15 g. Pregnancies were recorded in late March to late April on Biliran and Leyte, and lactating females were captured in July on Mt. Makiling, Luzon (Ingle, 1992; Rickart et al., 1993).

Males average slightly larger than females in most cranial and external measurements (Table 11; Rickart et al., 1993). This species exhibits some geographic variation; careful study is needed. Cranial measurements of Kitanglad specimens are similar to those from Biliran and Leyte, smaller than those from Mt. Isarog, Luzon, and slightly larger than those from Catanduanes (Heaney et al., 1991, 1999; Rickart et al., 1993). Sedlock (2001) has described the echolocation call on Luzon. One specimen from Leyte Island had a karyotype of 2N = 58, FN = 60 (Rickart et al., 1999).

SPECIMENS EXAMINED—Total 21. Site 2 (8 FMNH); Site 5 (7 FMNH); Site 6 (3 FMNH); Site 15 (3 FMNH).

Rhinolophus macrotis Blyth, 1844

The big-eared horseshoe bat ranges from India to Sumatra and the Philippines. Within the Philippines, it is poorly known, with records from about 50 m to 1050 m in primary and secondary lowland forest; they are known to roost in caves and man-made tunnels (Esselstyn et al., 2004; Heaney et al., 1998; Sedlock, 2001).

We captured none, but two specimens from an unknown locality on Mt. Kitanglad are housed in the SMF; their cranial measurements are similar to those of specimens from elsewhere in the Philippines (Table 11; Ingle & Heaney, 1992). Ingle and Heaney (1992) noted that the Philippine population is morphologically distinct from specimens from elsewhere. Sedlock (2001) described the echolocation call on Luzon.

SPECIMENS EXAMINED—Total 2. Unknown site (2 SMF).

Rhinolophus virgo K. Andersen, 1905

The yellow-faced horseshoe bat is endemic to the Philippines. It is widespread and common in primary and secondary lowland forest from sea level to 1100 m, and infrequent in montane forest up to 1475 m; it often roosts in caves and crevices (Esselstyn et al., 2004; Heaney et al., 1998, 2006; Sedlock, 2001). In April 1992, we captured a single adult male (6 g) in old-growth lowland forest at 1100 m (Site 2; Table 10). Direct comparison with specimens from Isabela (FMNH 147160–147161) and Sorsogon (FMNH 147162) showed these to be nearly identical, whereas specimens from Mt. Makiling, Laguna Province, Luzon (FMNH 166406–166408), are clearly smaller and different in shape. Cranial and external measurements (Table 11) of the Kitanglad specimen are similar to those from Catanduanes, Leyte, and Maripipi (Heaney et al., 1991; Rickart et al., 1993), but specimens from Palawan have slightly smaller external measurements and larger toothrow measurements. This probably represents a species complex; more specimens and further study are needed. Sedlock (2001) described the echolocation call of the smaller morph from Luzon referred to above.

SPECIMENS EXAMINED—Total 1. Site 2 (1 FMNH).

Family Vespertilionidae

Kerivoula hardwickii (Horsfield, 1825)

The common woolly bat is widely distributed from India and southern China to the Lesser Sundas and the Philippines, where it occurs in primary and secondary lowland to mossy forest, from 60 m to 1600 m (Esselstyn et al., 2004; Heaney et al., 1998). On the Kitanglad Range, we netted one in residual montane forest at 1450 m (Site 15) and two in old-growth montane forest at 1600 m elevation (Site 3; Table 10); all three specimens were adult males.

Specimens from Site 3 (FMNH 147080–147081) have cranial and external measurements comparable to the specimens from Biliran, Leyte, Luzon, and Palawan (Table 12; Esselstyn et al., 2004; Rickart et al., 1993), and are virtually identical to a specimen from San Ramon, Mindanao (FMNH 33028). The specimen from Site 15 (FMNH 166467) has a similar cranial shape, but it is slightly smaller than the other specimens and has a proportionately shorter rostrum (Table 10). This specimen is not referable to any other recognized species of *Kerivoula*; more specimens and further study are needed to resolve relationships within this group.

SPECIMENS EXAMINED—Total 3. Site 3 (2 FMNH); Site 15 (1 FMNH).

Miniopterus australis Tomes, 1858

A widespread species from India to Australia, the little bent-winged bat occurs throughout the Philippines except the northernmost islands. This species typically roosts in caves from sea level to 200 m elevation, in agricultural areas and second-growth lowland forest (Esselstyn et al., 2004; Heaney et al., 1998). We captured an adult female in secondary montane forest at 1450 m (Site 15), the highest elevation recorded for this species in the Philippines. Cranial and external measurements (Table 12) and direct comparison show it to be virtually identical to series at FMNH from Tegato, Mindanao, and to specimens from Guimaras, Negros, Palawan, and Polillo islands.

SPECIMENS EXAMINED—Total 1. Site 15 (1 FMNH).

Miniopterus schreibersi (Kuhl, 1819)

The common bent-winged bat is found from Europe to the Solomon Islands and throughout the Philippines, commonly in caves in agricultural areas and in primary lowland and montane forest, from sea level to 1450 m (Esselstyn et al., 2004; Heaney et al., 1998; Sedlock, 2001). On Mt. Kitanglad, we netted one specimen, an adult male (9 g) with testis size of 2×2.5 mm, from old-growth lowland forest at 1100 m in April (Site 2; Table 10). Direct comparison with specimens from Mt. Isarog, Luzon (FMNH 152041), Negros (FMNH 142880–142883), and Palawan (FMNH 168936–168938) showed no evident differences, and cranial and external measurements (Table 12) are closely similar to those for the specimens from Mt. Isarog. Specimens reported from Leyte tend to be slightly larger (Esselstyn et al., 2004; Heaney et al., 1999;

TABLE 12. Mean ± SD and range of selected external and cranial measurements of adult evening and free-tailed bats (Vespertilionidae and Molossidae) from the Kitanglad Range, Mindanao, Philippines. Sample size smaller than n is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	n	Total length	Tail length	Hindfoot	Ear	Forearm	Weight (g)	Condylo-incisive length	Zygomatic breadth	Interorbital width	Mastoid breadth	Rostral length	C^1 to last M	Molariform tooth row
Kerivoula hardwickii "large"	M	2	84	40	8	14	34	4	12.7	8.5	3.2	7.0	3.1	5.0	3.5
			84–85	40	8–9	14–15	34	4–5	12.5–12.9	8.5 (1)	3.1–3.2	6.8–7.3	3.0–3.1	4.9–5.1	3.5–3.6
Kerivoula hardwickii "small"	F	1	81	42	7	12	32.9	4.0	12.3	8.2	3.2	7.1	3.3	5.0	3.4
Miniopterus australis	F	1	100	49	8	—	43	8	13.6	7.6	3.5	7.7	4.3	5.4	3.8
Miniopterus schreibersi	F	1	105	45	10	13	41	9	15.2	8.6	3.7	8.3	4.7	6.2	4.6
Murina cyclotis	M	1	92	36	11	16	35	7	15.8	9.7	4.6	8.3	4.2	5.4	4.4
	F	1	85	32	11	16	37	8	15.4	9.4	4.4	—	3.7	5.7	4.4
Myotis sp.	F	1	81	35	10	13	33	6	12.7	—	3.0	7.0	4.2	5.0	3.7
Philetor brachypterus	M	2	94	36	10	14	36	13	13.9	10.8	4.7	8.7	3.4	4.6	3.8
			93–96	35–36	10	13–15	36–37	11–15	13.5–14.3	10.2–11.3	4.5–4.9	8.4–9.0	3.3–3.6	4.6	3.7–3.8
	F	1	95	36	10	14	36	14	14.2	10.6	4.6	8.9	3.6	4.6	3.8
Pipistrellus javanicus "large"	M	4	88 ± 2.2	36 ± 0.82	10 ± 0.6	12 ± 0.6	36 ± 0.9	7 ± 1.0	13.2 ± 0.04	8.9 ± 0.36	3.6 ± 0.20	7.8 ± 0.12	3.4 ± 0.06	5.0 ± 0.08	3.9 ± 0.10
			85–90	35–37	9–10	12–13	35–36	6–8	13.2–13.3	8.9–9.0	3.4–3.8	7.6–7.9	3.3–3.5	4.9–5.1	3.8–4.0
	F	1	84	36	9	13	37	6	13.2	9.0	3.8	8.2	3.4	5.1	3.9
Pipistrellus javanicus "small"	M	10	80 ± 1.2	32 ± 2.4	9 ± 0	12 ± 0.9 (9)	34 ± 0.7	5 ± 0.5	12.5 ± 0.17	8.2 ± 0.16 (7)	3.5 ± 0.14	7.2 ± 0.14	3.2 ± 0.09	4.4 ± 0.12	3.5 ± 0.08
			78–82	26–35		10–13	33–35	5–6 (9)	12.2–12.7	8.0–8.4	3.3–3.7	7.0–7.5	3.1–3.3	4.3–4.6	3.4–3.6
	F	2	84 (1)	34 (1)	8 (1)	12 (1)	34 (1)	7 (1)	12.0	8.0 (1)	3.3	7.0	3.1	4.1	3.4
									11.9–12.1		3.2–3.5	6.8–7.2			3.4–3.5
Pipistrellus sp.	F	1	84	34	10	12	38	6	13.3	—	4.2	7.9	3.2	4.8	3.4
Otomops sp.	M	1	116	34	11	28	54	18.8	18.9	10.7	4.2	10.4	5.1	7.5	5.2

Rickart et al., 1993). Sedlock (2001) described the echolocation call on Luzon.

SPECIMENS EXAMINED—Total 1. Site 2 (1 FMNH).

Murina cyclotis Dobson, 1872

The round-eared tube-nosed bat ranges from Sri Lanka to Hainan, Borneo, and the Philippines. Philippine records are from within the Luzon, Mindanao, and Sibuyan faunal regions, where it has been documented in primary and lightly to heavily disturbed lowland and montane forest from 250 m to 1500 m (Heaney et al., 1998; Sedlock, 2001). On Kitanglad in April 1992, we obtained two specimens in old-growth lowland forest at 1100 m elevation (Site 2; Table 10). An adult female (8 g) was pregnant with a single embryo (CRL = 6 mm). The adult male had scrotal testes. Pregnant and lactating females were recorded in April and May on Mt. Isarog, Luzon (Heaney et al., 1999).

External and cranial measurements (Table 12) of both specimens are consistently smaller than those of specimens from the islands of Biliran and Catanduanes, and even smaller than those of specimens from Mt. Isarog, Luzon (Heaney et al., 1991, 1999; Rickart et al., 1993). Sedlock (2001) has described the echolocation call on Luzon. Specimens from Luzon had a karyotype of 2N = 44, FN = 50 (Rickart et al., 1999).

SPECIMENS EXAMINED—Total 2. Site 2 (2 FMNH).

Myotis sp.

On Mt. Kitanglad in April 1992, we netted a single small, dark brown *Myotis* (adult female, 6 g; FMNH 147067) in old-growth lowland forest at 1100 m (Site 2; Table 10). It was pregnant with a single embryo (CRL = 21 mm). The braincase is domed, rising sharply from the rostrum, which is relatively long and narrow. The canines are long, and the upper unicuspid (PM^2) is present but small and only slightly out of line in the toothrow. The base of the thumb is not broad and fleshy, but rather is similar to those of *Myotis muricola browni*. In these features, this specimen differs from *Myotis rossetti* and *Myotis ridleyi* of Southeast Asia (Corbet & Hill, 1992), but is similar to those of *Myotis ater* and *Myotis muricola*, from which it differs in size (Table 12).

Myotis ater is known from Vietnam and peninsular Malaysia to Sulawesi, the Mollucas, and New Guinea (Simmons, 2005). We reexamined specimens previously referred to *M. muricola* from the Philippines, and are readily able to refer series from several localities to this larger species. Specimens from Culion Island, Palawan Province (FMNH 63653–63654, 63679–63681) originally referred to *Myotis nugax* by Sanborn (1952), and two specimens from Mt. Isarog, southern Luzon originally referred to *M. muricola* (USNM 573778–573779; Heaney et al., 1999) have measurements nearly identical to those given by Hill (1983) and Corbet and Hill (1992) for *M. ater*, and share the broader rostrum and zygomatic arches, more inflated braincase, and proportionately smaller PM^3 relative to *M. muricola*.

Other series we examined are typical *M. muricola browni*; these include specimens from Negros Island (FMNH 145546), from Cagayan (176551), Kalinga (FMNH 167239), and Laguna (FMNH 177469) provinces on Luzon Island, plus previously examined specimens with published measurements from Biliran, Leyte, and Maripipi islands (Rickart et al., 1993) and the holotype of *M. muricola browni* from Saub, Cotabato Province, Mindanao (Taylor, 1934). These data demonstrate that the two species are broadly sympatric over at least part of the Philippines.

Our single specimen from Kitanglad differs from both *M. ater* and *M. muricola*, and does not fit within any other species of *Myotis* from Southeast Asia (Corbet & Hill, 1992) or Wallacea (Flannery, 1995). For this reason, we do not assign it to any species at this time.

SPECIMENS EXAMINED—Total 1. Site 2 (1 FMNH).

Philetor brachypterus (Temminck, 1840)

The short-winged pipistrelle is distributed from Nepal to New Guinea, and occurs throughout most of the Philippines where it has been documented in primary and disturbed lowland forest from 475 m to 900 m (Heaney et al., 1998; Sedlock, 2001). On Kitanglad, we netted an adult male in disturbed lowland forest at 800 m (Site 1) and three others in residual montane forest at 1450 m (Site 15; Table 10). An adult female (14 g) netted in April was pregnant with a single near-term embryo (CRL = 25 mm) and an adult male (15 g) netted in November had scrotal testes.

In most external and cranial measurements (Table 12), the Kitanglad specimens are similar to those from Leyte and Mt. Isarog, Luzon

(Heaney et al., 1999; Rickart et al., 1993), and to specimens from Catanduanes (FMNH 140603) and Negros (FMNH 145548). Sedlock (2001) has described the echolocation call from Mt. Makiling, Luzon.

SPECIMENS EXAMINED—Total 4. Site 1 (1 FMNH); Site 11 (3 FMNH).

Pipistrellus javanicus group

Although recent publications on Philippine pipistrelles have considered only a single species from the *P. javanicus* group to be present (e.g., Heaney et al., 1998, 1999), a study on Mt. Makiling, Laguna Province, Luzon, indicates that specimens previously referred to *P. javanicus* represent two species, which differ in echolocation calls and also have slight morphological differences in pelage, body size, and skull morphology (Sedlock, 2001). Examination of 30 specimens from Mt. Kitanglad revealed two and perhaps three species. We report on these briefly here, but note the importance of more extensive study.

The majority of the specimens from Kitanglad are small, with condylo-incisive length of adults averaging 12.52 mm for males and 11.98 mm for females, forearm of 34.0 mm (males) and 34 mm (females), and total length of 80.4 mm for males and 84 mm for females (Table 12). This small morph includes 24 individuals from Sites 2, 3, 5, 6, and 15 (Table 10). These are quite similar to specimens of the smaller morphotype from Mt. Makiling, Laguna (FMNH 142035, 142041–142045), as well as specimens from Kalinga Province, Luzon (FMNH 167237–167238). Although these represent the smallest *Pipistrellus* from Kitanglad, they are substantially larger than *Pipistrellus tenuis* (Ingle & Heaney, 1992).

Five additional adult specimens from Kitanglad (FMNH 147069–147070, 147072, 147076, 147854) are larger, with condylo-incisive length averaging 13.21 for four males and 13.18 mm for one female, forearm of 35.5 mm and 37 mm, and total length of 88.2 mm and 84 mm for males and females, respectively (Table 12). They are similar in size to a large morphotype from Mt. Makiling, Luzon (FMNH 142036, 166446–166449), but some external features appear to differ, and the two large morphotypes may represent different species (Sedlock and Heaney, unpubl. data). These larger bats were captured at Sites 2 (1100 m; 3 of 5), 4 (one from 1800 m), and 5 (1900 m; 1 of 2), indicating a lower elevational range than the small morphotype.

There is no size overlap between the "small" and "large" morphotypes from Kitanglad; those individuals nearest in size are separated by more than 0.5 mm in condylo-incisive length. In addition to differences in cranial size, these two morphotypes differ in the attachment of the plagiopatagium on the lateral side of the ankle (Sedlock and Heaney, unpubl. data), in the degree of swelling of the soft tissue on the rostrum, and in the color of the ventral pelage.

In addition to these two well-defined morphotypes on Kitanglad, a single subadult taken at 1450 m (Site 15; FMNH 166473) is large, with condylo-incisive length (13.26 mm), forearm (37.7 mm), and total length (84 mm) and most other measurements similar to the "large morphotype" but with a wider interorbital region; this specimen may simply represent a young individual of the large morphotype, but more study is needed.

In both morphotypes, males outnumbered females by at least four to one. An adult female of the small morphotype captured in early May had a swollen uterus and was lactating.

Specimens of what appears to be a large morphotype from Mt. Isarog, Luzon, had a karyotype of 2N = 38, FN = 48, which differs from that of Malaysian specimens referred to *P. javanicus* (Rickart et al., 1999).

SPECIMENS EXAMINED—Total 30. Site 2 (5 FMNH); Site 3 (2 FMNH); Site 4 (1 FMNH); Site 5 (2 FMNH); Site 6 (15 FMNH); Site 15 (5 FMNH).

Family Molossidae

Otomops sp.

Mastiff bats of the genus *Otomops* occur from Africa to New Guinea. A specimen from Balbalasang, Kalinga Province, Luzon, represented the first published Philippine record (Heaney et al., 2005a), but the first captured was one from Baguio, Benguet Province, Luzon, taken on 15 July 1991 by R. I. Crombie (FMNH 142615). In August 1999, R. Baylomo and A. Pepay captured an adult male (19 g) with scrotal testes (FMNH 167382) in residual montane forest at 1450 m (Site 15; Table 10). In most external and cranial measurements (Table 12) the Kitanglad specimen is notably smaller than those from Luzon, and there are cranial shape differences; the Philippine specimens of *Otomops* are under study by J. Eger (pers. comm.).

SPECIMENS EXAMINED—Total 1. Site 15 (1 FMNH).

Order Primates
Family Tarsiidae

Tarsius syrichta (Linnaeus, 1758)

The Philippine tarsier is endemic to the Mindanao Faunal Region, with records from the islands of Basilan, Biliran, Bohol, Dinagat, Leyte, Maripipi, Mindanao, Samar, and Siargao. It is common in primary and secondary lowland forest and shrubby agricultural areas from sea level to 700 m (Dagosto & Gebo, 1997; Neri-Arboleda & Arboleda, 2002; Rickart et al., 1993).

Although we obtained no specimens on Kitanglad, we observed tarsiers in disturbed lowland forest at 825 m (Site 1). In 1951, the DPE collected a single female at 450 m in Cabanglasan, Bukidnon, close to the boundary with Agusan (Sanborn, 1953). A radio-tracking study in the wild on Leyte indicated a small home range in males, ca. 0.6–2.0 ha, typically with three to four sleeping sites within a home range (Dagosto et al., 2001). The same study showed that foraging and traveling are done close to the ground, mainly at 1–2 m above ground.

Specimens from Mindanao and Leyte had karyotypes of 2N = 80 (Rickart, 2003).

SPECIMENS EXAMINED. None.

Family Cercopithecidae

Macaca fascicularis (Raffles, 1821)

The long-tailed macaque occurs from Burma to Timor and throughout the Philippines, where it occurs in primary and secondary lowland forest and primary montane forest, and in adjacent agricultural areas from sea level to 1800 m (Fooden, 1995; Heaney et al., 1998). On Kitanglad, we sighted the species in disturbed lowland forest at 875 m (Site 1), old-growth lowland forest at 1100 m (Site 2), residual montane forest at 1450 m (Site 15), old-growth montane forest at 1600 m (Site 3), transitional montane/mossy forest at 1800 m (Site 4) and 1900 m (Site 5), and old-growth mossy forest at 2250 m (Site 6).

According to the local farmers and hunters near Site 15 in 1997–1999, monkeys were formerly more common, often raiding gardens planted with corn on the lower slopes. We were in the forest at this site on almost a daily basis for many months, but the long-tailed macaque was rarely heard or seen. When seen, no more than 10 individuals were observed. Local people hunted the monkeys for sale as pets to local buyers, to agents supplying monkey farms near Manila, and for food. A lower mandible was found in a hunter's hut at 1100 m (Site 12), along with rodent and flying fox mandibles.

SPECIMENS EXAMINED—Total 1. Site 12 (1 FMNH).

Order Rodentia
Family Sciuridae

Exilisciurus concinnus (Thomas, 1888)

The Philippine pygmy squirrel is endemic to and widespread within the Mindanao Faunal Region, with records from Basilan, Biliran, Bohol, Dinagat, Leyte, Mindanao, Samar, and Siargao. It occurs in primary and secondary lowland and montane forest from sea level to 2000 m (Heaney, 1985; Heaney et al., 1998). On the Kitanglad Range, we caught single individuals in old-growth montane forest at 1350 m (Site 14), in residual montane forest at 1450 m (Site 15), and in transitional montane/mossy forest at 1800 m (Site 4; Fig. 8). The specimens collected at Sites 13 and 14 were caught by local residents using unbaited native traps called *giman*. In addition, we observed several individuals running quickly along fallen logs on the ground at the edge of *kaingin* and partially logged lowland forest at 825 m (Site 1); another was seen scampering up a tree trunk in old-growth montane forest at 1600 m (Site 3). They produced a sharp chirp similar to that of Holarctic chipmunks (*Tamias*). Two adult males and an adult female were collected in April 1960 in transitional montane/mossy forest at 1800 m (Site 20). Stomach contents of two females contained finely ground pale and reddish-brown plant materials, and both also contained roughly chewed arthropod larvae.

Three adult females weighed an average of 31 g (range = 25–35 g), one of which, caught in May at Site 4, was pregnant with a single embryo (CRL = 12 mm) and another, caught in April at Site 15, had a swollen uterus. The pregnant female was multiparous and had three placental scars. A female (25 g) captured in September at Site 14 had large mammae but no visible placental scars.

In most external and cranial measurements (Table 13), the Kitanglad specimens are slightly larger than those from Biliran, Dinagat, Leyte, and Siargao, but indistinguishable from specimens taken elsewhere on Mindanao (Heaney, 1985; Heaney & Rabor, 1982; Rickart et al.,

Table 13. Mean ± SD and range of selected external and cranial measurements of adult squirrels (Sciuridae) and murid rodents (Muridae) from the Kitanglad Range, Mindanao Island, Philippines. Sample size smaller than n is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	n	Total length	Tail length	Hindfoot	Ear	Weight (g)	Basioccipital length	Interorbital width	Zygomatic breadth	Mastoid breadth	Nasal length	Maxillary molarifom toothrow	Diastema
Exilisciurus concinnus	M	2	—	—	—	—	—	—	10.4 (1)	—	12.2 (1)	7.5 (1)	3.6 (1)	6.6
														6.5–6.7
	F	3	165	72	28	12 (1)	30	25.0	10.8	17.5	12.4	8.2	4.1	6.7
			163–167 (2)	69–74 (2)	27–28 (2)		25–35 (2)	24.9–25.2	10.6–10.8	17.1–17.8 (2)	12.3–12.5	7.8–8.6	3.8–4.3	6.6–6.8
Petinomys crinitus	M	2	—	—	—	—	—	61.1	11.5	39.8	26.3	19.6	13.8	13.2
								60.8–61.3	11.1–11.9	38.9–40.8	26.1–26.6	19.1–20.0	13.8	13.1–13.2
	F	1	—	—	—	—	—	62.9	13.1	40.1	27.8	21.0	13.2	15.4
Apomys hylocoetes	M	15	249 ± 9.2	142 ± 6.0	32 ± 1.2	20 ± 0.9	39 ± 3.1	28.7 ± 0.60	5.2 ± 0.18	15.2 ± 0.34	12.9 ± 0.34	12.5 ± 0.41	6.0 ± 0.18	7.3 ± 0.32
			227–260 (12)	132–152	29–33	18–22	34–45	27.1–29.5	5.0–5.5	14.3–15.8	12.4–13.6	11.4–13.0	5.6–6.4	6.6–7.7
	F	15	246 ± 6.5	139 ± 7.0	32 ± 1.0	20 ± 0.5	36 ± 3.3	28.4 ± 0.57	5.2 ± 0.12	15.0 ± 0.28	12.7 ± 0.25	12.4 ± 0.45	6.0 ± 0.21	7.2 ± 0.33
			239–260	127–149	31–34	19–21	28–40	27.1–29.3	4.9–5.3	14.6–15.4	12.4–13.2	11.5–13.3	5.6–6.3	6.8–7.9
Apomys insignis	M	20	252 ± 9.2	147 ± 5.5	33 ± 0.9	20 ± 0.9	38 ± 2.6	27.9 ± 0.52	5.0 ± 0.20	14.8 ± 0.41	12.4 ± 0.36	11.6 ± 0.40	6.0 ± 0.15	7.0 ± 0.29
			231–266 (12)	139–157 (12)	32–35 (14)	18–21 (14)	35–43 (14)	27.0–28.8	4.6–5.4	14.0–15.5 (17)	12.0–13.2	10.8–12.3	5.7–6.3	6.5–7.6
	F	19	252 ± 10.3	147 ± 9.1	33 ± 1.0	20 ± 0.5	39 ± 5.2	27.8 ± 0.54	5.1 ± 0.17	14.8 ± 0.34	12.4 ± 0.36	11.7 ± 0.54	6.0 ± 0.16	7.0 ± 0.24
			236–272 (12)	134–162 (12)	32–35 (13)	19–20 (12)	33–52 (13)	27.1–28.7	4.8–5.4	14.3–15.4 (16)	11.8–13.4 (16)	10.7–12.9	5.6–6.1	6.7–7.5
Batomys salomonseni	M	15	310 ± 11.0	130 ± 8.9	37 ± 1.2	22 ± 1.3	180 ± 14.6	38.8 ± 1.03	6.2 ± 0.28	21.4 ± 0.90	15.2 ± 0.51	17.6 ± 0.68	7.9 ± 0.21	11.4 ± 0.45
			297–329 (11)	123–141 (11)	35–39 (12)	21–25 (12)	150–195 (9)	36.8–40.8 (14)	5.8–6.7	20.0–23.1	14.3–16.1 (11)	16.4–18.9	7.5–8.2	10.2–12.5
	F	16	308 ± 14.3	132 ± 8.3	37 ± 1.2	23 ± 1.2	174 ± 25.3	38.6 ± 1.06	6.2 ± 0.30	21.2 ± 0.80	15.1 ± 0.29	17.7 ± 0.82	7.8 ± 0.25	11.4 ± 0.45
			291–335 (8)	124–150 (8)	34–38 (9)	21–24 (9)	138–205 (6)	37.5–40.9 (15)	5.8–6.9 (15)	19.5–22.8	14.7–15.6	16.4–19.4 (15)	7.3–8.2	10.2–12.1
Bullimus bagobus	M	1	483	205	60	28	635	58.2	8.8	31.0	22.6	26.4	10.4	17.3
Crunomys melanius	M	3	220* (2)	95* (2)	28	15 (2)	60	29.6	5.9	14.1	12.9	11.2	4.3	7.9
					28–29		50–71	28.0–30.6	5.7–6.1	13.6–14.4	12.3–13.2	10.6–12.0	3.9–4.7	7.6–8.2
Crunomys suncoides	M	1	209	101	33	16	37	27.4	5.8	12.4	11.7	11.6	3.5	7.7

1993). The Binukid name for the species is *tambalingan*.

SPECIMENS EXAMINED—Total 6. Site 4 (1 FMNH); Site 14 (1 FMNH); Site 15 (1 FMNH); Site 20 (3 FMNH).

Petinomys crinitus Hollister, 1911

The Mindanao flying squirrel is endemic to the Mindanao Faunal Region, where it occurs in lowland forest from 500 m to 1600 m on the islands of Basilan, Dinagat, Mindanao, and Siargao (Heaney et al., 1998).

On the Kitanglad Range in May 1960, two adult males and an adult female were collected in montane forest at ca. 1300 m (Site 18). We obtained no specimens but observed many individuals in old-growth lowland forest at 1100 m (Site 2); the long, silky brown fur and nearly black markings around the eyes, ears, neck, and tail were easily visible with a flashlight. We heard and saw dozens of them as they chattered loudly and frequently, and chased each other, gliding from tree to tree and then crashing onto a branch in the canopy. We saw no evidence that they went to the ground; our lowest observation was ca. 10 m above ground. The peak of their activity was from 1800 h to 1845 h, though we heard them occasionally throughout the night. On one occasion, a pair was observed mating at early dusk between 1710 h and 1745 h on a large horizontal tree branch, ca. 30 m above ground. They were common at 850 m in second-growth lowland forest (Site 1). We heard fewer of them in old-growth montane forest at 1600 m (Site 3), and we heard none in the old-growth montane forest sites at higher elevations (Fig. 8).

Cranial measurements (Table 13) are larger than those reported for specimens from Dinagat and Siargao, and from Davao Province, Mindanao (Heaney & Rabor, 1982). No assessment has been made of geographic variation.

SPECIMENS EXAMINED—Total 3. Site 18 (3 FMNH).

Sundasciurus philippinensis (Waterhouse, 1839)

The Philippine tree squirrel is endemic to the Mindanao Faunal Region, with records from Basilan, Biliran, Bohol, Dinagat, Leyte, Mindanao, Samar, and Siargao. It occurs in primary and secondary lowland and montane forest from sea level to 2100 m, and often in agricultural areas adjacent to forest (Heaney et al., 1998). We captured no specimens during our survey, but we observed them in disturbed lowland forest at 825 m (Site 1), in old-growth lowland forest at 1100 m (Site 2), and less often in old-growth montane forest at 1600 m (Site 3) and in transitional montane/mossy forest at 1800 m and 1900 m (Sites 4 and 5). We did not encounter them at sites in the mossy forest at 2250 m and above (Fig. 8). We most often saw them in the trees, but occasionally on the ground, the reverse of our observations of pygmy squirrels. The Binukid-speaking people on Kitanglad call this squirrel *laksoy* or *kolagsoy*.

A specimen from Biliran Island had a karyotype of 2N = 38 (Rickart et al., 2003).

SPECIMENS EXAMINED—None.

Family Muridae—Rats and Mice

Apomys hylocoetes Mearns, 1905

The Mindanao mossy forest mouse is endemic to Mindanao, where it currently is known only from Mt. Apo and the Kitanglad Range (Heaney et al., 1998), but it is probably widespread at high elevations. Overall, it was the most common of the murid rodents we encountered on the Kitanglad Range, and second in abundance only to *Podogymnura truei* among the non-volant small mammals. The absence of captures in lowland and montane forest, despite considerable trapping effort, shows that they do not occur in such habitats. All of our specimens were all captured in old-growth mossy forest (Sites 5–9; Table 2, Fig. 8), and the species appears to be restricted to that habitat. From March to June 1993, 81 specimens were captured, of which 42 were males and 39 were females. All were taken in traps set on the ground along runways, under fallen logs and among moss-covered root tangles. Trapping results indicate a strongly nocturnal or crepuscular activity pattern, with 66 of 68 captures (97%) occurring during that period (Table 3).

In 1993, we captured this species in proportion to the availability of bait, indicating comparable preference for roasted coconut and earthworms (Table 4). Stomach contents of 40 individuals included both finely ground grayish-brown plant materials and arthropod exoskeletons (Table 5), indicating an omnivorous feeding habit.

We captured 31 adult, four young adult, and four subadult females. Among adults, 10 pregnant females had a mean weight of 37 ± 2.3 g (range = 33–39 g) and each had a single embryo. One female had an embryo with CRL of 32 mm; nine had embryos with mean CRL of 5 ± 2.6 mm (n = 9, range = 1–8 mm). Eight of the pregnancies were detected in March and

April, and two in May. During the same period, 13 non-pregnant, multiparous females had a mean weight of 36 ± 2.3 g (range = 33–41 g). Six multiparous females that we autopsied had mean placental scars of 2 ± 1.8 (range = 1–5 scars) and weighed 37 ± 2.3 g (range = 35–41 g). Eight females were nulliparous (33 ± 3.3 g, range = 28–35 g). Four subadults (nulliparous, with subadult pelage) were taken in March and April.

The males consisted of 36 adults, four young adults, and two subadults. In March to June, adult males with scrotal testes had a mean weight of 39 ± 2.7 g (n = 31, range = 35–44 g). Testis size ranged from 4 × 9 mm to 9 × 15 mm (n = 14). Young adults had a mean weight of 32 ± 1.2 g (n = 4), and all had abdominal testes, including one with a testis size of 4 × 7 mm. The two subadults (28 g, 29 g) had abdominal testes; one of these had a testis size of 2 × 4 mm.

External and cranial measurements (Table 13) show only very slight variation between males and females. Externally, *A. hylocoetes* is similar to *Apomys insignis*, but differs most conspicuously in having a shorter tail, shorter and broader hind feet, and a longer rostrum (Musser, 1982a). Molecular data indicate that *A. hylocoetes* and *A. insignis* are sister species that differentiated recently; their closest relative is an undescribed species from Leyte and Biliran islands (Heaney & Tabaranza, 2006; Steppan et al., 2003). However, the two species exhibit major chromosomal differences; *A. hylocoetes* has a standard karyotype of 2N = 48, FN = 56, whereas *A. insignis* has 2N = 36, FN = 72 (Rickart & Heaney, 2002). Morphological (Musser & Heaney, 1992) and molecular (Jansa et al., 2006) data show *Apomys* to be a member of an endemic Philippine clade that includes *Archboldomys*, *Chrotomys*, and *Rhynchomys*.

SPECIMENS EXAMINED—Total 81. Site 5 (7 FMNH); Site 6 (59 FMNH); Site 7 (9 FMNH); Site 8 (2 FMNH); Site 9 (4 FMNH).

Apomys insignis Mearns, 1905

The Mindanao montane forest mouse is endemic to Mindanao and Dinagat; we tentatively include *A. littoralis* as a junior synonym (Heaney, unpubl. data). It occurs in primary and secondary lowland and montane forest from sea level up to 2800 m (Musser & Heaney, 1992; Fig. 8). These mice were generally common on the Kitanglad Range; we captured them in residual montane forest at 1450 m (Site 15) and old-growth montane forest at 1600 m (Site 3) at low numbers, and at high density in transitional montane/mossy forest at 1800 m and 1900 m (Sites 4 and 5, respectively; Table 2, Fig. 8). Overall, we captured 65 specimens (35 females and 30 males). In 1960, 16 specimens were taken at 1300 m (Site 18) and 1500 m (Site 19), and one at 1800 m (Site 20). The Binukid name for *Apomys* in Lupiagan is *alunsian*, but two residents from the neighboring village of Occasion called them *kalansiak* or *konsiyal*.

In 1992, all 58 of the captures for which we recorded time of capture were nocturnal/crepuscular (Table 3). Captures were in proportion to the availability of the two bait types, indicating equal preference for earthworms and roasted coconut (Table 4). At Site 15, six specimens were trapped by local people in unbaited native snap traps called *giman*. We examined stomachs of 35 individuals (many nearly full), most of which contained mainly finely ground pale to dark brown plant materials. Nearly all stomachs also held small amounts of arthropod exoskeletons, but these were not as abundant as in *A. hylocoetes* (Table 5). These results indicate an omnivorous species, but one that is probably more reliant on plant foods than is *A. hylocoetes*.

The females captured in 1992–1993 and 1999 consisted of 22 adults, four young adults, and five subadults. Five of the adults and one of the young adults were pregnant and had a mean weight of 40 ± 3.2 g (range = 36–44 g). Two of the females had twins; the rest had single embryos each. One had a relatively large embryo (CRL = 23 mm); the others had smaller embryos with a mean CRL of 6 ± 2.9 mm (range = 3–10 mm). Three non-pregnant but multiparous females had an average weight of 40 g (range = 38–40 g). The five subadults (31 ± 5.0 g, range = 24–38 g) and three young adults (32 g, range = 26–35 g) were nulliparous. Pregnancies were detected from March to May.

Males captured during the same period consisted of 30 adults, four young adults, and two subadults. Adults had a mean weight of 39 ± 2.2 g (n = 15, range = 35–41 g). Testis size ranged from 5 × 4 mm to 12 × 5 mm (n = 8). The young adults had a mean weight of 36 ± 4.3 g (n = 4, range = 32–42 g); one of these had a testis size of 4 × 3 mm. The subadults weighed 25 g and 26 g, and one had a testis size of 4 × 2 mm.

External and cranial measurements (Table 13) showed only very slight variation between the

sexes. This species had a standard karyotype of 2N = 36, FN = 72 (Rickart & Heaney, 2002).

SPECIMENS EXAMINED—Total 82. Site 3 (5 FMNH); Site 4 (31 FMNH); Site 5 (23 FMNH); Site 15 (5 FMNH, 1 PASU); Site 18 (7 FMNH); Site 19 (9 FMNH); Site 20 (1 FMNH).

Batomys salomonseni (Sanborn, 1953)

The Mindanao hairy-tailed rat is endemic to the Mindanao Faunal Region, with records from the islands of Biliran, Dinagat, Leyte, and Mindanao (Heaney et al., 1998; Musser et al., 1998). On the smaller islands, it occurs from 500 m to 950 m (Rickart et al., 1993). On the Kitanglad Range, which is the only place on Mindanao it has been documented, we found it at 1450 m and 1500 m in residual montane forest (Sites 15, 16, and 17), at 1800 m and 1900 m in transitional montane/mossy forest (Sites 4 and 5), and in old-growth mossy forest at 2250 m (Site 6) and 2375 m (Site 7; Fig. 8). None was captured in old-growth lowland forest at 1100 m (Site 2), and they appear to be absent in such habitat. We did not take any in old-growth mossy forest at 2600–2800 m (Sites 8 and 9), but sampling intensity was lower at those sites (Table 2). Two males and a female were collected in December 1951 in montane forest on Kitanglad at 1600 m (Site 23), one of which is the holotype (Sanborn, 1953). In 1960, seven specimens were collected at 1500 m (Site 19) and one at 1800 m (Site 20).

All but one individual for which we recorded time of capture were nocturnal/crepuscular captures, showing significant preference for nocturnal activity (Table 3). All of our specimens in 1992–1993 were taken in traps set on the ground, usually along runways, under root tangles, under rotting fallen trees, or under the bases of standing live or dead trees. Nearly all were in places with moss that was several centimeters thick on the ground and on trees and logs. The specimens taken at Sites 15, 16, and 17 were caught in unbaited native snap traps called *giman*, and snares called *bayobo* and *balod*. Based on interviews with Binukid-speaking villagers, local people commonly trapped this species for food, along with the other forest-dwelling rodents (NORDECO & DENR, 1998).

We captured significantly more *B. salomonseni* with coconut bait than with earthworms (Table 4). Stomachs of 19 individuals all contained finely divided plant material; none contained fragments of earthworms or arthropods (Table 5). This species appears to be entirely herbivorous.

The 21 females captured in 1992–1993 and 1999 consisted of one juvenile, two subadults, two young adults, and 16 adults. Four adults were pregnant in March and had a mean weight of 190 ± 14.7 g (range = 170–195 g). Two of them each had a single embryo (CRL = 34 mm and 50 mm) and two each had twins (CRL = 22 mm and 23 mm). Non-pregnant multiparous females averaged 160 ± 18.4 g (n = 10, range = 130–187 g). Placental scars ranged from 1–2 (n = 4). Two young adults (140 g and 120 g) were nulliparous. Two subadults weighed 98 g and 110 g; the juvenile was 59 g.

Among the 20 males captured during the same period, there were two juveniles, three subadults, one young adult, and 14 adults. All the adults (167 ± 20.7 g, n = 14, range = 125–195 g) had scrotal testes which ranged in size from 15 × 23 mm to 20 × 40 mm (n = 9). The young adult (135 g) also had scrotal testes that measured 14 × 28 mm. The subadults had an average weight of 101 g (n = 3, range = 92–120 g) whereas the juveniles weighed 67 g and 105 g. One subadult had testis size of 5 × 10 mm, while one juvenile had a testis size of 5 × 8 mm.

Adult males and females do not differ in most external and cranial measurements (Table 13). Overall, specimens from Kitanglad are slightly smaller than those from Leyte (Rickart et al., 1993). Specimens from Kitanglad and from Leyte Island had standard karyotypes of 2N = 52, FN = 52 (Rickart & Musser, 1993). Molecular data (Jansa et al., 2006) support the placement of *Batomys* in an endemic Philippine clade that includes *Carpomys*, *Crateromys*, and *Phloeomys* (Musser & Heaney, 1992).

SPECIMENS EXAMINED—Total 50. Site 4 (4 FMNH); Site 5 (14 FMNH); Site 6 (16 FMNH); Site 7 (3 FMNH); Site 15 (1 FMNH); Site 16 (2 FMNH); Site 17 (1 FMNH); Site 19 (7 FMNH); Site 20 (1 FMNH); Site 22 (1 FMNH).

Bullimus bagobus Mearns, 1905

The large Mindanao forest rat is endemic to the Mindanao faunal region, with records from Bohol, Dinagat, Leyte, Maripipi, Mindanao, Samar, and Siargao. Previous studies found it to be widespread in lowland to mossy forest from 200 m to 1800 m (Heaney et al., 1998), often in heavily disturbed habitat (Sanborn, 1952), although sometimes in old growth forest (Rickart

et al., 1993); records from Mindanao cover the entire elevational range (Fig. 8). We captured none during the 1992–1993 field seasons at our study sites. In August and September 1999, an adult and a young adult male and one young adult female were captured in residual montane forest at 1350 m and 1450 m (Sites 14 and 15) by Binukid villagers. The males weighed 635 g and 330 g, respectively, and both had scrotal testes. The female (360 g) had small mammae, but was primiparous with two small (2 mm) uterine swellings. On Leyte and Maripipi, a post-lactational female was noted in April by Rickart et al. (1993).

Our three specimens were collected in residual forest by two trappers using the unbaited native snap traps called *giman*. In contrast, our standard trapping techniques in old-growth forest, using both live and snap traps baited with coconut and peanut butter or with live earthworms, did not catch any. This suggests that either our techniques are ineffective in catching this species, or the animals were absent in the upland old-growth forest, or possibly both.

One of the trappers said that the female, on which the distal 5 cm of the tail was white, was a *takobong*, and that the two adult males, one which had no white to the tail and the other had white only on the extreme tip, were *kawili*. These two names were also assigned to the similar-looking *Rattus everetti*. It was clear that both names were used interchangeably for both species, more likely in reference to white tail-tip variants rather than to species-specific combinations of external characters. Interviews with Binukid-speaking villagers on Kitanglad suggest that local people commonly trapped this species for food, along with the other forest-dwelling rodents (NORDECO & DENR, 1998).

Our one adult male had external and cranial measurements (Table 13) that are at the large end of the range for males from Biliran, Leyte, Dinagat, and Siargao, all of which are smaller than those from Mt. Malindang, Mindanao (Heaney & Rabor, 1982; Rickart et al., 1993). A specimen from Leyte Island had a standard karyotype of 2N = 42, FN = 58 (Rickart & Musser, 1993). Molecular data indicate that *B. bagobus* is most closely related to *Bullimus gamay*, a species endemic to Camiguin Island, and less closely to *Bullimus luzonicus*; *Bullimus* appears to be most closely related to *Sundamys*, which occurs on the Sunda Shelf of Southeast Asia (Jansa et al., 2006; Rickart et al., 2002).

SPECIMENS EXAMINED—Total 3. Site 14 (2 FMNH); Site 15 (1 FMNH).

Crunomys melanius Thomas, 1907

The southern Philippine shrew-mouse is endemic to the Mindanao faunal region and the adjacent oceanic island of Camiguin. It was previously recorded in old-growth lowland forest from sea level to 900 m on Leyte and Mindanao (Heaney et al., 1998; Rickart et al., 1998), and on Camiguin in disturbed lowland agricultural land and in montane forest in second growth and a mosaic of old growth and landslides from 1000 m to 1275 m (Heaney et al., 2006). In April 1992, we captured two adults, a female and a male, in old-growth montane forest at 1550 m (Site 3; Table 1, Fig. 8). Both were captured during daytime (Table 3) in traps baited with coconut and peanut butter set near small holes in the ground. The male was captured at the base of a live tree with thick moss, and the female between large rocks along a steep cliff; neither appeared to be going for the bait, but rather to have bumped into the bait pedal (Table 4). The female (58 g) was multiparous but not pregnant. An adult male was captured in September 1999 in grassland adjacent to a small creek and the residual montane forest at 1450 m (Site 15) using the native *giman* snap trap. The Binukid-speaking trapper who brought in the specimen said that the local name is *ayugan*, that they are scarce, and that they decompose very quickly in the traps (within 3 days).

The cranial dimensions (Table 13) fit well with a specimen from Leyte (Rickart et al., 1993), but appeared to be slightly smaller than specimens from Camiguin (Heaney et al., 2006). Molecular data indicate that *Crunomys* is not closely related to other genera in the Philippines, with the possible exception of *Maxomys* (Jansa et al., 2006).

SPECIMENS EXAMINED—Total 6. Site 3 (2 FMNH); Site 11 (1 FMNH); unknown (3 SMF).

Crunomys suncoides Rickart, Heaney, Tabaranza, and Balete, 1998

The Kitanglad shrew-mouse is currently known only from the Kitanglad Range (Rickart et al., 1998), though we suspect that it is more widespread in mossy forest on Mindanao. The species was described based on a single adult

male (FMNH 147942; 37 g) we captured in April 1993 in old-growth mossy forest at 2250 m (Site 6, Fig. 8). It had scrotal testes measuring 14 × 8 mm. Externally, this species is easily distinguished from *C. melanius* by a combination of unique characteristics including orange-brown pelage, large brown front feet with long, stout claws, and a bi-colored tail that is nearly as long as the combined head and body length (Rickart et al., 1998; Table 13). The specimen was caught in mid-afternoon (Table 3) in a trap baited with a live earthworm (Table 4) set under root tangles at the base of a small ravine. The stomach was empty so its feeding habits remain unknown. Rickart et al. (1998) hypothesized that it is similar to *Archboldomys luzonensis*, which is diurnal and feeds on soft-bodied invertebrates. A semi-fossorial habit is inferred from a combination of external characters, including strong front feet with large claws, narrow head, tiny eyes, and dense, soft pelage (Rickart et al., 1998).

This species has a standard karyotype of 2N = 36, FN = 36 (Rickart et al., 1998).

SPECIMEN EXAMINED—Total 1. Site 5 (1 FMNH).

Limnomys bryophilus Rickart, Heaney and Tabaranza, 2003

The buffy-collared moss mouse was discovered during the course of our survey in 1993. We recorded it in old-growth mossy forest at 2250 m, 2375 m, 2600 m, and 2800 m (Sites 6–9; Fig. 8). Although currently known only from the Kitanglad Range, we suspect that it occurs more widely on Mindanao, especially in mossy forest on mountains in the Central Mindanao geological sector (see Geological History, above; Fig. 2). On Kitanglad, the elevational range of *L. bryophilus* overlaps with that of its sole congener, *Limnomys sibuanus* (Fig. 8); both were recorded in old-growth mossy forest at 2250 m (Site 6). This species is distinguished externally from *L. sibuanus* by its longer tail that has a white 1–4 mm tip and by its longer and wider hind foot; its greater basicranial, nasal, and molariform toothrow length (Table 13); and its dark brown dorsum and pale ash venter, with a pale brown (buffy) collar in the throat region (Rickart et al., 2003). Molecular data confirm that *Limnomys* and *Tarsomys*, each with two known species, form a monophyletic clade confined to Mindanao (Jansa et al., 2006), as suggested on the basis of morphological data (Musser & Heaney, 1992).

We recorded a total of 25 specimens (9 females and 16 males). The females, all captured in March, April, and June, consisted of three young adults and six adults. The young adults (47 g, 54 g, and 55 g) were nulliparous. The adults had a mean weight of 67 ± 8.1 g (range = 58–80 g); five were noted as having large mammae but were not pregnant. The one juvenile weighed 29 g, and the young adults had a mean weight of 50 ± 2.8 g (n = 5, range = 47–54 g). The adults had a mean weight of 73 ± 13.0 g (n = 9, range = 57–94 g). All the adults had scrotal testes; two of these had testis size of 12 × 19 mm and 13 × 20 mm. Three of the young adults had scrotal testes of 4 × 6 mm and 5 × 9 mm.

All 16 individuals for which time of capture was recorded were taken at night (Table 3). Although trapping data suggest equal preference for earthworms and roasted coconut (Table 4), stomach contents of 16 individuals consisted of finely ground, dark brown plant materials and some small white seeds (Table 5), indicating the predominance of plant material in the diet. Most individuals were noted as being captured on steep slopes, either under root tangles of live trees or beside fallen logs in places with heavy growth of moss at the trap site and in the surrounding habitat.

A noticeable temporal difference in average weight of all individuals exists between earlier captures at the lower elevations at Sites 5 and 6 and later ones at higher elevations at Sites 7 and 8. Overall, the average weight in earlier captures was at least 7 g (in females) to 10 g (in males) less than the later ones. In both sexes, the weight difference was because of the proportionately greater number of subadults and young adults captured in March and April; proportionately more adults were captured in May and June. Similar temporal variation in weight was observed in *Apomys musculus* and *Rattus everetti* on Mt. Isarog where the young of the year, estimated to have been born around the third quarter of the year (July–September), were gaining weight and approaching adulthood and sexual maturity in April–June (Balete, 1995; Balete & Heaney, 1997; Heaney et al., 1999). This would also imply that *Limnomys bryophilus*, as with *A. musculus* and *R. everetti* on Mt. Isarog, probably breeds once a year and that the young of the year become reproductively active near the end of their first year.

External and cranial measurements (Table 14) show that females are slightly larger than males

TABLE 14. Mean ± SD and range of selected external and cranial measurements of adult murid rodents (Muridae) from the Kitanglad Range, Mindanao Island, Philippines. Sample size smaller than n is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters. All measurements of *Tarsomys echinatus* taken from Musser (1994).

Species	Sex	n	Total length	Tail length	Hindfoot	Ear	Weight (g)	Basioccipital length	Interorbital width	Zygomatic breadth	Mastoid breadth	Nasal length	Maxillary molarifom toothrow	Diastema
Limnomys	M	3	296	168	32	22	58	31.6	4.9	17.3	14.2	12.4	5.7	8.7
bryophilus			291–305	163–173	31–34	21–22	54–64	31.2–32.1	4.8–5.0	17.3 (2)	14.2–14.3	12.3–12.6	5.7	8.4–8.9
	F	3	300	171	32	22	70	33.3	5.0	17.8	14.7	13.6	6.1	9.1
			290–307	157–180	30–34	20–24	58–80	32.9–33.9	5.0–5.1	17.5–18.0	14.4–14.9	13.2–14.2	5.9–6.4	8.9–9.3
Limnomys	M	1	294	160	30	22	52	31.1	4.9	16.3	14.2	12.6	4.8	8.8
sibuanus	F	3	276	149	28	21	57	30.3	4.9	16.5	14.2	11.8	4.7	8.6
			266–286	147–151	28–29	20–22	52–60	30.1–30.5	4.9–5.0	16.1–16.9	14.2–14.3	11.5–12.6	4.6–4.8	8.1–9.0
Mus musculus	F	2	155	82	16	12	16	18.8	3.4	9.6	8.0	—	3.1	4.7
			151–159	79–84	15–16	12–13	12–21	18.2–19.5	3.4–3.5	9.1–10.2	7.5–8.4		3.1–3.2	4.5–4.9
Rattus everetti	M	5	523 (1)	252 (1)	53 (1)	27 (1)	490 (1)	53.0 ± 1.85	7.1 ± 0.28	26.4 ± 1.44	18.7 ± 0.33	21.2 ± 1.60	10.1 ± 0.25	15.1 ± 1.07
								51.4–56.0	6.9–7.4	25.3–28.7	18.3–19.2	19.7–23.8	9.8–10.4	15.3–17.0
	F	5	466 (1)	229 (1)	49 (1)	27 (1)	220 (1)	49.7 ± 2.10	7.8 ± 0.18	25.7 ± 0.98	18.4 ± 0.43	20.6 ± 1.25	9.8 ± 0.30	13.8 ± 1.01
								48.2–52.8 (4)	7.5–7.9	24.8–27.4	18.0–19.0	19.0–22.5	9.4–10.0	13.1–15.6
Rattus exulans	M	5	259	132	26	16	48 (1)	29.8 ± 0.65	4.9 ± 0.19	14.9	12.6 ± 0.34	11.6 ± 0.40	5.4 ± 0.25	8.0 ± 0.17
			253–265 (2)	129–134 (2)	25–27 (3)	14–17 (3)		28.9–30.5	4.6–5.1	14.4–15.4 (3)	12.2–13.1	11.1–12.2	5.0–5.6	7.7–8.2
	F	1	240	124	26	16	36	28.9	4.6	14.4	12.5	—	5.1	7.7
Rattus tanezumi	M	3	366	190	36	22	170	39.4	6.3	19.9	15.5	14.7	7.5	10.7
			355–377	181–200	35–38	22–23	169–171	39.2–39.6 (2)	6.2–6.5	19.5–20.2	15.3–15.6 (2)	13.9–15.8	7.3–7.7	10.4–11.2
	F	2	364 (1)	192 (1)	38 (1)	21 (1)	160 (1)	40.7	6.6	20.8	15.9	16.0 (1)	7.2	10.5
								39.3–42.1	6.4–6.7	20.2–21.3	15.1–16.7		7.1–7.2	10.1–10.9
Tarsomys	M	2	262	122	34	22	71	34.5	6.2	18.5	14.6	14.7	6.1	10.1
apoensis			260–263	119–126	33–34	21–22	70–72	34.3–34.7	6.0–6.4	18.0–19.0	14.4–14.8	14.7	6.1	9.9–10.2
	F	1	245	116	31	22	65	33.1	5.8	17.4	13.9	13.6	6.0	9.0
Tarsomys	M	1	—	96	30	—	—	35.7[1]	5.6	—	—	10.8[2]	—	9.9
echinatus	F	1	—	—	29	—	—	35.8[1]	5.6	17.9	—	11.2[2]	5.9	10.2

[1] Greatest length of skull (occipitonasal length).
[2] Length of rostrum.

in most dimensions. This species has a standard karyotype of 2N = 42, FN = 61/62 (Rickart & Heaney, 2002).

SPECIMENS EXAMINED—Total 25. Site 6 (15 FMNH); Site 7 (1 FMNH); Site 8 (4 FMNH); Site 9 (5 FMNH).

Limnomys sibuanus Mearns, 1905

The white-bellied moss mouse is endemic to Mindanao Island, where it was previously known from primary mossy forest from 2000 m to 2800 m on Mt. Apo, Mt. Kitanglad, and Mt. Malindang (Heaney et al., 1998; Musser, 1994). The species is characterized by a relatively long tail, long and slender hind feet, long digits, short recurved claws, and prominent palmar and plantar pads, all suggestive of scansorial or possibly arboreal habits (Musser & Heaney, 1992; Rickart et al., 2003). On the Kitanglad Range, we captured a total of 10 specimens in transitional montane/mossy forest at 1900 m (Site 5), and old-growth mossy forest at 2250 m (Site 6), usually a bit lower in elevation than the locations where *L. bryophilus* was captured (Fig. 8).

All 10 individuals were captured at night (Table 3). They showed equal preference for roasted coconut and earthworms as bait (Table 4), but the small sample size makes this a weak test. In captivity, a live individual readily accepted small ripe fruits, fresh coconut, dried mangoes, and live weevils, but only marginally accepted unripe fruits, cooked rice, and fried coconut; rejected raisins, live cockroach and land snail after investigation; and ignored mushrooms, shelf fungus, snake meat, acorns, and dried fish and shrimp. Stomach contents of four individuals consisted mainly of finely ground dark and light brown plant materials, with no evidence of arthropods or earthworms (Table 5). The feeding trials and results of stomach analysis indicate that it is a granivore/frugivore, with some tendency toward omnivory.

Five females captured in March consisted of a juvenile (31 g), a young adult (47 g) and three adults (mean = 57 g, range = 52–60 g). One adult was lactating; the two others had large mammae and both had swollen uteri, indicating that both had given birth recently. The five males caught during the same period consisted of a young adult (48 g) and three adults with a mean weight of 67 g (range = 54–82 g). Three males had scrotal testes, two of which had testes measuring 9 × 15 mm and 11 × 18 mm.

The adults of both males and females show little or no sexual dimorphism in cranial and external measurements (Table 13). The Kitanglad Range specimens are similar to two from Mt. Apo, and *L. sibuanus* from both localities are slightly larger than specimens from Mt. Malindang, but sample sizes are small (Musser & Heaney, 1992; Musser, 1994; Rickart et al., 2003). This species has a standard karyotype of 2N = 42, FN = 61/62 (Rickart & Heaney, 2002).

SPECIMENS EXAMINED—Total 10. Site 5 (4 FMNH); Site 6 (6 FMNH).

Mus musculus Linnaeus, 1758

The house mouse is a cosmopolitan species, usually associated with human habitation in rural and urban areas in the Philippines, rarely above 100 m (Heaney et al., 1998). Apparently house mice do not occur in forest habitats in the Philippines, even on islands with depauperate native faunas where other alien species become established in forest. We captured none at our forest sites in 1992–1993. In March 1999, eight individuals were captured in a house in the village of Lupiagan at 1200 m (Site 13), where the Binukid-speaking people called them *danggit*. The Silliman University group collected an adult female in May 1960 at ca. 1300 m (Site 18), where *Rattus exulans* and *Rattus tanezumi* were also taken, along with several native species. Our 1999 specimens consisted of four females and four males. Among the females, two were nulliparous young adults (7 g and 9 g) with small mammae. The other two were adults with large mammae; one was pregnant (21 g) with five embryos (CRL = 20 mm), the other (12 g) was not pregnant. All the males were young adults (mean = 9 ± 0.8 g (n = 4, range = 8–10 g), including two with scrotal testes.

External and cranial measurements are presented in Table 13. Specimens from Negros Island had karyotypes of 2N = 40, FN = 40, identical to those reported from mainland Asia (Rickart & Heaney, 2002).

SPECIMENS EXAMINED—Total 9. Site 13 (7 FMNH, 1 PASU); Site 18 (1 FMNH).

Rattus everetti (Gunther, 1879)

The common Philippine forest rat is the most widespread endemic murid rodent in the Philippines, occurring on most islands except those in the Batanes/Babuyan, Palawan, and

Sulu faunal regions. It occurs in shrubby agricultural areas and in disturbed and primary lowland to mossy forest from sea level to 2400 m (Heaney et al., 1998). Its elevational range on Mindanao is second only to *Crocidura beatus* (Fig. 8). On the Kitanglad Range in April and May 1992, we obtained a total of seven specimens in primary lowland forest at 1100 m (Site 2), primary montane forest at 1600 m (Site 3), and primary mossy forest at 1800 m (Site 4). In March, September, and October 1999, nine specimens were captured in residual montane forest at 1350 m (Site 14) and 1450 m (Site 15), and transitional montane/mossy forest at 1500 m (Site 17). Additionally, in March 1960, 11 specimens were captured at 1300 m (Site 18). Despite more than 5,100 trap-nights in primary transitional montane/mossy forest at 1900 m to 2800 m (Sites 5 to 9), none was captured at these sites. These data are consistent with earlier evidence that this species is primarily associated with low and middle elevations, especially in disturbed forest, and much less frequently with mossy forest, except in areas of disturbance (Heaney et al., 1989, 1998; Rickart et al., 1991, 1993). Many of our specimens were captured in association with large fallen logs or large rocks on steep slopes. On Mt. Isarog, Luzon, this species is partially arboreal (Balete & Heaney, 1997; Heaney et al., 1999).

We captured one individual during daylight, but the species was significantly nocturnal/crepuscular (Table 3). The stomachs of five individuals all contained finely ground plant matter that appeared to be seeds, and four of these also contained traces of arthropod exoskeletons (Table 5).

The specimens captured in April and May 1992 consisted of three males and four females. Among the females, one was a juvenile (90 g), one was a subadult (220 g), and two were adults (280 g and 355 g). Neither of the adults was pregnant. Among the males, one was a subadult (240 g), and two were adults (410 g and 490 g) with scrotal testes measuring 31 × 18 mm and 32 × 20 mm. In October 1999, the nine specimens consisted of five males and four females. Among the females, one was a subadult (227 g) and three were adults, of which two were pregnant (298 g and 322 g). Both pregnant females were primiparous and had three (CRL = 15 mm) and four (CRL = 10 mm) embryos, respectively. Among the males, one was subadult (223 g), and the other four were adults with a mean weight of 350 ± 35.3 g (range = 310–380 g). All adult males had scrotal testes.

Specimens taken in March 1960 consisted of seven females and four males, including four sub- and young adults of both sexes. Overall, of the 21 specimens captured in March–May (1960, 1992, and 1999), nine (43%) were juveniles, subadults, and young adults. These data suggest strongly seasonal reproduction, with births occurring near the transition between wet and dry seasons.

Our trappers said the Binukid name was *takobong* or *kawili*, names also given to *Bullimus bagobus*. Three lower mandibles we found in a hunter's hut indicate that this species is trapped for food. Interviews of Binukid-speaking villagers on the Kitanglad Range suggest that they collect these and other large species of rodents in the forest, both native and non-native, for food (NORDECO & DENR, 1998).

Males are slightly larger than females in most external and cranial measurements (Table 14). Overall, Kitanglad specimens are intermediate between those from Dinagat and Siargao, which are larger, and those from Biliran, Camiguin, Catanduanes, Leyte, Luzon (Mt. Isarog), and Maripipi, all of which are slightly smaller (Heaney, 1984; Heaney & Rabor, 1982; Heaney et al., 1991; 1999, 2006; Rickart et al., 1993). Size variation among specimens from the different islands is notable and a detailed analysis of geographic variation is needed. Heaney et al. (2005b) found evidence of genetic differentiation between populations of this species in each of the faunal regions where they occur. Specimens from the Mindanao Faunal Region had a standard karyotype of 2N = 42, FN = 64, similar to those from Catanduanes and southern Luzon (Rickart & Musser, 1993).

SPECIMENS EXAMINED—Total 27. Site 2 (2 FMNH); Site 3 (4 FMNH); Site 4 (1 FMNH); Site 14 (3 FMNH); Site 15 (3 FMNH, 1 PASU); Site 17 (2 FMNH); Site 18 (11 FMNH).

Rattus exulans (Peale, 1848)

The spiny ricefield rat is found from Bangladesh to Easter Island and throughout the Philippines, where it commonly occurs in agricultural areas at all elevations, as well as in disturbed forest (Heaney et al., 1998). It usually does not occur in forest, but on islands that have few native rodent species, such as Camiguin and

Negros, it is present in high-elevation old-growth forest (Heaney et al., 1989, 2006; Heideman et al., 1987). On Mt. Kitanglad in 1993, we captured a single specimen at night in transitional montane/mossy forest at 1900 m (Site 5). In March and July 1999, five were taken in residual montane forest at 1350 m and 1450 m (Sites 13 and 14, respectively), of which four were snap-trapped in a small house that was surrounded by grassland but within 200 m of the residual forest, and the other one was caught in a native trap in the residual forest within 40 m of grassland (Site 14). In March 1960, two specimens were captured in montane forest at 1300 m (Site 18), the same site where *Mus musculus* and *Rattus tanezumi* also were captured. The Binukid name is *alunsian*, also given to *Apomys insignis*, which is of similar size. One trapper also called it *kalibangkug*.

Neither of the two adult females (48 g and 56 g), captured in March and July, nor the young adult (36 g) captured in July, was pregnant. Among the four males captured in 1993, one was a young adult (39 g) and the rest were adults, two of which weighed 48 g each. All the males had scrotal testes; these measured 9 × 15 mm to 10 × 17 mm (n = 3).

External and cranial measurements (Table 14) fall within a series from Leyte but are slightly smaller than those from Camiguin, Dinagat, and Mt. Apo (Heaney & Rabor, 1982; Heaney et al., 2006; Rickart et al., 1993). Specimens from Negros Island had standard karyotypes of 2N = 42, FN = 60, similar to those from elsewhere in Southeast Asia (Rickart & Musser, 1993).

SPECIMENS EXAMINED—Total 9. Site 5 (1 FMNH); Site 14 (1 PASU); Site 15 (5 FMNH); Site 18 (2 FMNH).

Rattus tanezumi Temminck, 1844

The Oriental house rat is a widespread commensal species found from Afghanistan to Indo-Malaya, New Guinea, Micronesia (except the Samoan islands), and throughout the Philippines (Heaney et al., 1998). This form has previously been referred to as *Rattus mindanensis* and *Rattus rattus mindanensis* (Musser & Carleton, 2005). Although they occur abundantly in close association with humans in urban and agricultural areas, they are sometimes also common in disturbed lowland and montane forest up to 1800 m. On some islands such as Negros with depauperate native small mammals, they occur in old-growth forest habitats (Heaney et al., 1989, 1998). However, this is not the case on Camiguin, where other alien species (*Suncus murinus* and *Rattus exulans*) have become established in old-growth forest (Heaney et al., 2006).

In March 1993, we obtained one specimen along an established trail in transitional old-growth montane/mossy forest at 1900 m (Site 5). In February–April 1999, seven were captured at 1450 m (Site 15), of which two came from a small house and the rest came from the nearby residual montane forest. A lower mandible was found in a hunter's hut at 1100 m (Site 12). In March 1960, the Silliman University group took two specimens at 1300 m (Site 18) and one at 1800 m (Site 20). In December 1951, the DPE recorded a female from Mt. Kaatoan at 1250 m (Site 22; Sanborn, 1953).

We captured two females in March 1999; both were adults (157 g and 160 g), neither of which was pregnant. Of the six males caught in 1993 and 1999, one was a young adult (115 g), two were subadults (61 g and 97 g), and the rest were adults with an average weight of 183 g (range = 169–209 g). The young adult and subadults were taken in March and April.

The specimens from Site 15 were obtained by a variety of methods. One was poisoned, one was found dead in the forest of unknown causes, and the rest were trapped in three types of unbaited native traps: *balod*, *latugpi*, and *giman*. The Binukid-speaking people on the Kitanglad Range called this species *ambao*, which is used to refer to rats in general, though one trapper also called it *malmag*. As evidenced by the lower mandible in a hunter's hut, and from results of interviews with local people on the Kitanglad Range, this species, as with several native species of rodents in the forest, is collected for food (NORDECO & DENR, 1998).

External and cranial measurements (Table 14) are similar to those of specimens from Biliran, Camiguin, Dinagat, Leyte, Maripipi, and Mt. Apo (Mindanao; Heaney & Rabor, 1982; Heaney et al., 2006; Rickart et al., 1993). Philippine specimens, from Biliran and Catanduanes, have a standard karyotype of 2N = 42; FN = 60, as do specimens from other parts of east Asia (Rickart & Musser, 1993).

SPECIMENS EXAMINED—Total 12. Site 5 (1 FMNH); Site 12 (1 FMNH); Site 15 (6 FMNH, 1 PASU); Site 18 (2 FMNH); Site 20 (1 FMNH).

Tarsomys apoensis Mearns, 1905

The dusky moss mouse is endemic to Mindanao Island, where previously it was known from montane and mossy forest at 1550 m to 2400 m on Mt. Apo, Mt. Kitanglad, and Mt. Malindang (Heaney et al., 1998; Musser & Heaney, 1992; Musser, 1994). In March–June 1993, we obtained 28 specimens in old-growth transitional montane/mossy forest and mossy forest at 1900 m and above (Sites 5–9; Table 2, Fig. 8). Earlier specimens from Kitanglad were collected in December 1951 at 1600 m (Site 23; Sanborn, 1953) and April 1960 in transitional montane/mossy forest at 1800 m (Site 20). All of our specimens were caught in traps set along runways and holes among mossy root tangles. They were active both day and night, in roughly equal proportion (Table 3). This is consistent with the prediction of Musser and Heaney (1992) of diurnal habits in this species, based on its rich chestnut ventral fur; this coloration is similar to that of diurnal forest-dwelling murids on Sulawesi (e.g., *Melasmothrix naso* and *Crunomys celebensis*) and in the Philippines (e.g., *Archboldomys luzonensis*; Musser, 1982b; Rickart et al., 1991).

Captures of 26 individuals showed a significant preference for earthworm bait, though to a lesser extent than *Podogymnura truei* (Table 4). Captive individuals accepted live earthworms, muscid and blue-bottle (caliphorid) flies, and small scarab beetles, but only marginally accepted a live cockroach, and completely rejected maggots, various small fresh fruits, dried mangoes, and coconut bait. They showed high preference for earthworms, but took considerable time to process them (much longer than the time needed by a *Rhynchomys isarogensis*; Rickart et al., 1993). One also attempted to catch flies that flew near the cage. The above feeding habits indicate a predominantly insectivorous animal, rather than a primary vermivore such as *Rhynchomys*. However, the stomach contents of 10 individuals (Table 5) consisted mainly of finely ground dark and light brown grainy plant materials, as well as some pulpy plant material. Five of these also contained discernible arthropod exoskeleton. This would suggest an omnivorous feeding habit in the wild, with a preference for animal matter.

The specimens captured in 1993 consisted of nine females and 19 males. Among the females, one was a young adult (61 g) and eight were adults with a mean weight of 82 ± 19.7 g (range = 65–125 g). One adult female (125 g) was pregnant in April with four embryos (CRL = 35 mm) and one was lactating but not pregnant (85 g) in June. Four adults had large mammae but were not pregnant. Four subadult males had a mean weight of 41 ± 7.5 g (range = 31–48 g), four were young adults with an average weight of 61 g (range = 57–65 g), and 11 were adults with a mean weight of 82 ± 17.6 g (range = 65–120 g).

External and cranial measurements are presented in Table 14. This species has a standard karyotype of 2N = 42, FN = 61/62 (Rickart & Heaney, 2002).

SPECIMENS EXAMINED—Total 29. Site 5 (4 FMNH); Site 6 (17 FMNH); Site 7 (3 FMNH); Site 9 (4 FMNH); Site 20 (1 FMNH).

Tarsomys echinatus Musser and Heaney, 1992

The Mindanao spiny rat was described from a series of specimens collected between about 800 m and 1100 m on Mt. Matutum, South Cotabato Province (Musser & Heaney, 1992; Fig. 2). The species later was reported from Kitanglad (Musser, 1994), based on specimens in SMF. No data on habitat or elevation are associated with the SMF specimens. We suspect that this species is associated with lowland forest (Heaney et al., 1998); additional surveys on Mindanao of areas below 1000 m are needed to gather information on this and other poorly known low-elevation mammals, such as *Crunomys melanius*.

SPECIMENS EXAMINED—None.

Order Carnivora
Family Viverridae

Paradoxurus hermaphroditus (Pallas, 1777)

The common palm civet occurs from Sri Lanka to Hainan, the Lesser Sunda Islands and throughout the Philippines, where it has been recorded in agricultural areas and forest, from sea level to 2400 m (Heaney et al., 1998). On Kitanglad, we trapped one specimen in transitional montane/mossy forest at 1800 m (Site 4). A second specimen, consisting of a lower mandible, was found in a hunter's hut at 1100 m in grassland (Site 12). The Binukid farmers on Kitanglad are very familiar with this animal since it often frequents human habitations near forested areas and is believed to occasionally raid their poultry. In Philippine forest, it is omnivorous, feeding on fruits and small mammals (Alcala & Brown, 1969; Heideman et al., 1987; Heaney et al., 1999).

The lower mandible collected in a farmer's hut indicates that this species is hunted for food, as it is on Mt. Isarog (Heaney et al., 1999). In August 1996, one of us (D.S.B.) observed a palm civet kept in a cage by a farmer living in a clearing in forest on Kitanglad. Along with ripe bananas, the farmer was feeding it live *Apomys* sp. trapped in the nearby forest.

Specimens from Leyte Island had standard karyotype of 2N = 42, FN = 61/62 (Rickart, 2003).

SPECIMENS EXAMINED—Total 2. Site 4 (1 FMNH); Site 12 (1 FMNH).

Viverra tangalunga Gray, 1832.

The Malay civet has been recorded from the Malay Peninsula to Sulawesi and Amboina, as well as throughout the Philippines, where it occurs in primary and secondary lowland forest to mossy forest, from sea level to at least 1200 m (Heaney et al., 1998). It is moderately common in the forest but rare elsewhere (Heaney et al., 1998). Stomach contents of an individual on Mt. Isarog consisted mainly of slugs and snails, whereas on Leyte, a female had parts of centipedes, snails, snakes, and skinks in its stomach (Heaney et al., 1999; Rickart et al., 1993). Another study found it to be more carnivorous, feeding on rodents and freshwater crabs (Auffenberg, 1988).

We did not collect any specimens on the Kitanglad Range. Local farmers reported that the animal lived in the area, but was not as common as *Paradoxurus hermaphroditus*. A specimen from Leyte Island had a standard karyotype of 2N = 36, FN = 64 (Rickart, 2003).

SPECIMENS EXAMINED—None.

Order Artiodactyla
Family Suidae

Sus philippensis Nehring, 1886

The Philippine warty pig is endemic to the Philippines, where it occurs from sea level to at least 2800 m on most islands of the Luzon, Mindanao, and Mindoro faunal regions (Heaney et al., 1998). It has been extirpated on the island of Marinduque and is now only common in remote forests throughout its range (Heaney et al., 1998, 2005a; Oliver, 1992, 1999). On the Kitanglad Range, we saw signs of pigs along a high ridge in montane/mossy forest at 1800 m, and tracks leading to pig wallows in mossy forest at 2000 m. In 1992 and 1993, local people told us that warty pigs were still present but heavily hunted and rarer than 5 yr previously. Several groups of pig hunters passed our camps; they had dogs to run down the pigs, and used knives and spears to kill them. A lower mandible was recovered from a hunter's hut in 1996 at 1100 m (Site 17). Local people brought a dead juvenile pig by our field house at Site 15. The pig had been killed with explosive bait that had been formed into balls, similar to what is popularly called "ping-pong" and commonly employed in some parts of Mindanao (Garcia & Deocampo, 1997). A specimen was taken in 1960 at ca. 1300 m (Site 18).

SPECIMENS EXAMINED: Total 2. Site 17 (1 FMNH); Site 18 (1 FMNH).

Family Cervidae

Cervus mariannus Desmarest, 1822

The endemic Philippine brown deer occurs throughout the Philippines except in the Batanes/Babuyan, Negros-Panay, Palawan, and Sulu faunal regions; it has been introduced to the Marianna Islands. It occurs in primary and secondary forest, from sea level to 2900 m (Grubb & Groves, 1983; Heaney et al., 1998). It is heavily hunted, and has been extirpated on the islands of Biliran and Catanduanes; in most parts of its former range, it is now found only in isolated forests (Heaney et al., 1999; Oliver et al., 1992).

On the Kitanglad Range, we saw fresh droppings, tracks, and trails of deer leading to a spring that flowed over a vertical rock face in mossy forest at 2300 m. One member of our crew saw an adult female along the ridge in mossy forest at 2000 m, in thick vegetation near a cogon (*Imperata cylindrica*) patch where a fire in 1982 had opened up the forest. We also heard two barking in the early evening, between 1830 h and 2000 h, and at dawn at Sites 5 and 6. The species seemed moderately common in our survey areas, but we believe that its population was declining, perhaps rapidly, because of continued illegal logging and hunting. In 1993, we met a local Binukid hunter on the lower slopes of the mountain with a deer he had killed for meat. In our camp in mossy forest at 2250 m (Site 6), we heard the hunters operating in the area several times. In 1960 two specimens were obtained at ca. 1300 m (Site 18) and one at ca. 1800 m (Site 20).

SPECIMENS EXAMINED—Total 3. Site 18 (2 FMNH); Site 20 (1 FMNH).

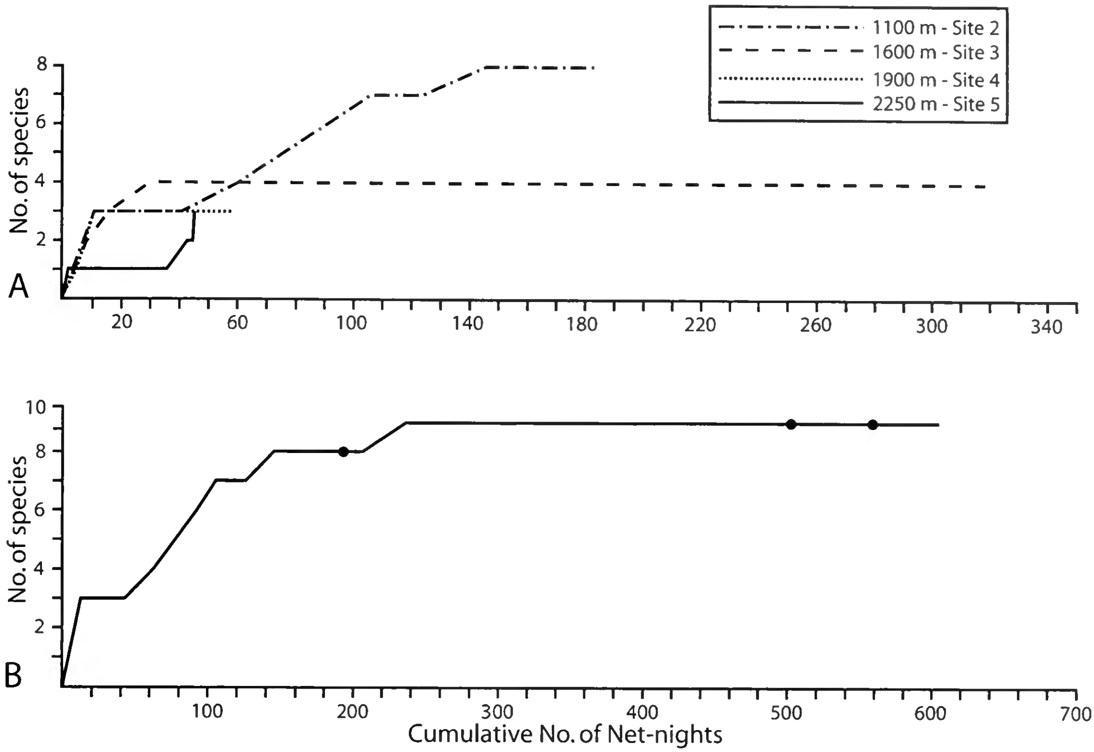

FIG. 10. Species accumulation curves for small fruit bats at Sites 2–6, by site (A) and additively for all sites (B). In B, dots separate portions of the curve from Sites 2, 3, 4, and 5.

Analysis and Discussion

Adequacy of Sampling

Before proceeding to analyze patterns of species distribution and richness, it is necessary to evaluate the extent and adequacy of sampling (Heaney et al., 1999). Prior to our studies, the fauna of the Mt. Kitanglad region (and Bukidnon Province in general) was considered to be poorly known on the basis of published records (Heaney et al., 2002).

As on other mountains in the Philippines, we found that three primary types of natural vegetation were present, as described in Study Sites (above): lowland, montane, and mossy forest. We sampled extensively for non-volant small mammals (Sites 2–9) and for bats (Sites 2–5) in all three types; we also sampled briefly for bats in disturbed lowland (Site 1) and extensively in disturbed montane forest (Site 15).

The combined species accumulation curve for small fruit bat species at Sites 1–6 shows a clear plateau (Fig. 10), indicating that all species on the mountain between 1100 m and 2250 m are likely to have been sampled. With well over 50 net-nights per site in old-growth forest at Sites 2–5 (Table 6), sampling should have been sufficient to obtain approximate species richness and proportional abundance of small fruit bats (Heaney et al., 1989; Heideman & Heaney, 1989). With 24 net-nights at Site 6 (2250 m), the common small fruit bat species should have been captured, but not all of the uncommon ones. Our sample of seven net-nights at Site 1 (825 m) was sufficient to document that some small fruit bats were present, but not to infer species richness, commonness, or proportional abundance. Additionally, the long-term, intensive netting at Site 15 produced 530 captures, and this is also likely to represent a nearly complete sampling of the small fruit bats for that site. We conclude that we can meaningfully analyze our data on small fruit bats, though recognizing the limits of our data for Sites 1 and 6. We have no data above Site 6 (2250 m), and so we can say little about the highest portions of the range.

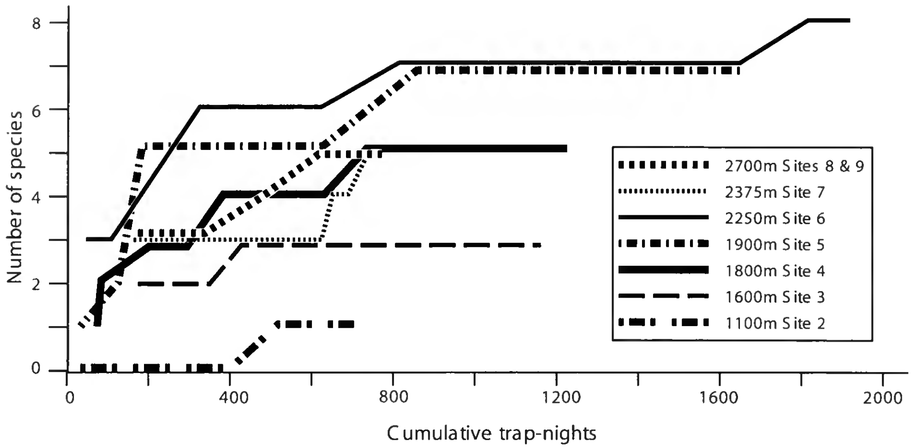

FIG. 11. Species accumulation curves from small mammal surveys at Sites 2–9, by site. Sites 8 and 9 are combined as 2700 m. Redrawn from Heaney (2001).

Large fruit bats, all of which fly high above the canopy, can be sampled only with high nets, and even then are difficult to capture. Although we obtained useful information on some species, we did not obtain enough data to estimate species richness or abundance.

Insectivorous bats, which use echolocation systems to navigate, often avoid mist nets, which were our only means of sampling. Although our results (Table 10) are sufficient to provide some information on habitat and elevation for some species, our data are not adequate to estimate species richness or abundance.

Sampling of small non-volant mammals at Sites 2–9 was moderately to highly intensive, with a range of 310 to 2,011 trap-nights per site (Table 2). Species accumulation curves for these sites (Fig. 11) shows that only a few species are added after 500 trap-nights, and plateaus are reached at about 800 trap-nights. When Sites 8 and 9 are combined, all of the sites have more than 500 trap-nights, and thus should yield reasonable estimates of species richness, although some locally rare species may have been missed. Similarly, these data should provide approximate proportional abundance, especially when densities were moderate to high and/or when the sampling effort exceeded 1,100 trap-nights (Heaney, 2001; Heaney et al., 1989, 1999; Rickart et al., 1991). Because our sampling above 2250 m (Sites 7–9) was not standardized for direct comparison, we do not include those data in the analyses that follow. Trapping at Site 15 for small non-volant mammals was not extensive and was conducted mostly by local people using traditional traps; these data provide important information about the ability of these species to maintain populations in disturbed montane forest, but cannot be directly compared to our standardized data. We note also that our sampling at Sites 1–9 was conducted from late March to early June, which encompasses the late dry season and early rainy season, and thus is not a complete sampling of the climatic variation.

Patterns of Species Richness of Small Fruit Bats

Small fruit bats were abundant and diverse at our standardized sampling areas (Table 8, Fig. 12). In comparison with Mt. Pangasugan (Leyte), Mt. Isarog (Luzon), and Mt. Guinsayawan (Negros; Heaney et al., 1999; Utzurrum, 1995), species richness follows a similar pattern of high richness in minimally disturbed lowland forest and general decline with increasing elevation. However, it is clear that species richness is higher on Kitanglad at any given elevation than on the other mountains. This may be an example of the "Massenerhebung" (mountain mass) effect, in which vegetation zones are displaced upwards on large and high mountain ranges (Flenley, 1995; Grubb, 1971; McCain, 2005). Aside from this effect, no differences are evident, providing support for the hypothesis that "patterns follow vegetation and climatic changes that are associated with elevation, and that elevation *per se* is less strongly correlated with species richness" (Heaney et al., 1999).

Our data on abundance of small fruit bats on the Kitanglad Range (Fig. 13) are largely con-

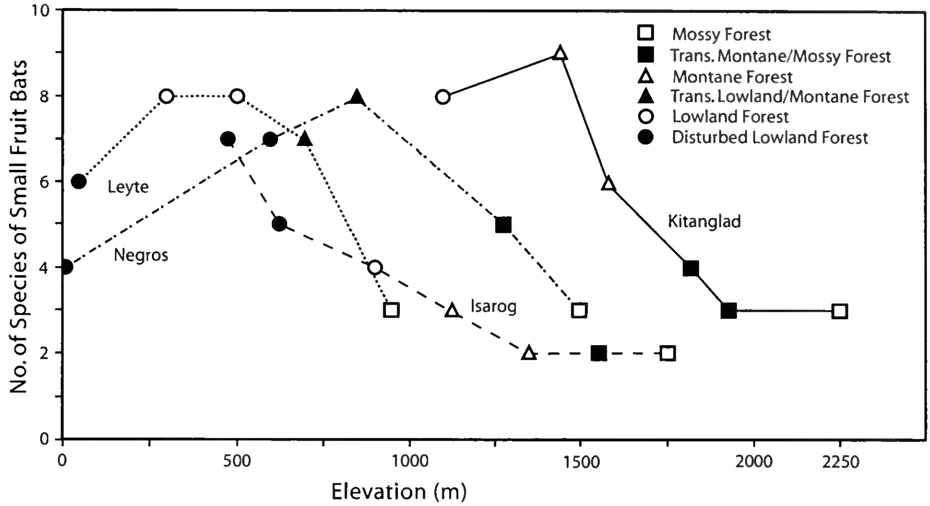

FIG. 12. Number of species of small fruit bats along four elevational transects (see text).

sistent with data from the three other mountains, but an important difference is evident. As on the other mountains, densities at all sites from 1100 to 2250 m are low, and decline is evident in moving from upper lowland forest to montane forest sites (from 0.91 to 0.30/net-night). However, transitional montane/mossy forest at 1900 m shows a slight increase in total abundance (0.63/net-night), and there is a substantial increase at 2250 m in mossy forest (1.21/net-night). This increase is because of the moderate abundance of *Haplonycteris fischeri* at 1900 m and high abundance of *Alionycteris paucidentata* at 2250 m (Table 8). Indeed, the relative abundance of *A. paucidentata* at 2250 m, 1.125/net-night, is the highest recorded for any species of small fruit bat at any site during our 1992–1993 field seasons. This confirms that *A. paucidentata* specializes in mossy forest habitat, a phenomenon unknown in any other Philippine bat (e.g., Heaney et al., 1998, 1999). When *A. paucidentata* is removed from the numbers for Site 6 (2250 m), the total abundance is in keeping with the patterns on the other three mountains (Fig. 13).

Patterns of Species Richness of Non-volant Small Mammals

The species richness of small mammals on the Kitanglad Range follows the same pattern that has been noted previously on Mt. Isarog (Luzon): richness increases steadily from lowland forest to the lower edge of mossy forest, and then declines with increasing elevation, yielding a curvilinear pattern (Fig. 14; Rickart, 1993; Rickart et al., 1991). Similar patterns have been documented on Borneo (Md. Nor, 2001), Taiwan (Yu, 1994), Costa Rica (McCain, 2004), and many other areas (McCain, 2005). Comparing Mt. Isarog and Kitanglad, it is clear that, although the pattern is the same, the increase on Kitanglad is shifted to higher elevations, with the peak near 2250 m, rather than at ca. 1500 m as on Isarog. As is the case with small fruit bats, this upward shift appears to be because of the "mountain mass effect," i.e., the upward displacement of vegetation zones on this high, large mountain. Also, the maximum species richness of small non-volant mammals on the Kitanglad

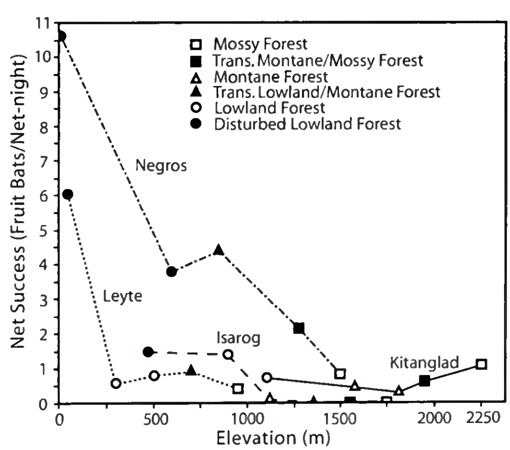

FIG. 13. Relative abundance of small fruit bats along four elevational transects (see text).

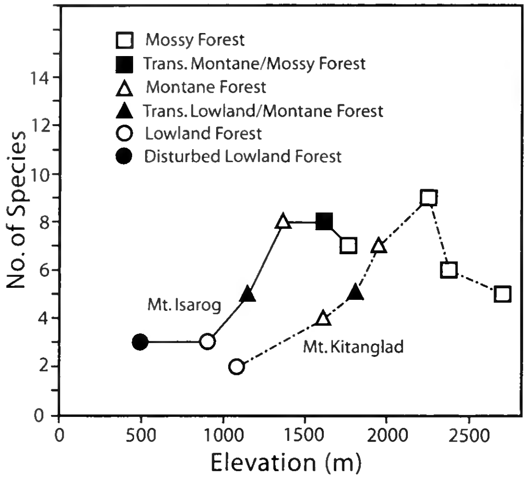

FIG. 14. Number of species of small mammals along two elevational transects (see text).

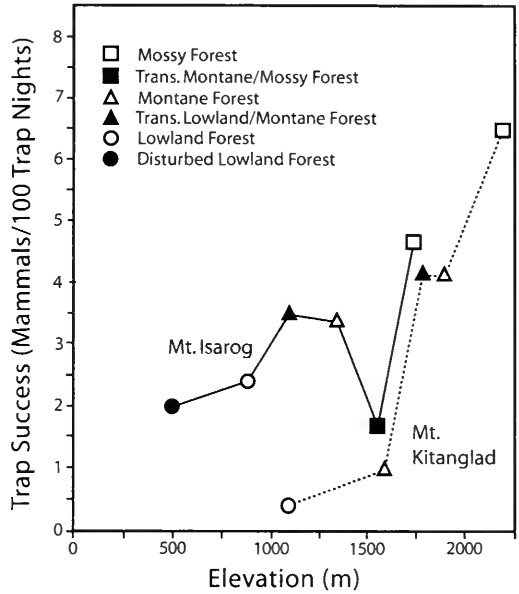

FIG. 15. Relative abundance of small mammals along two elevational transects (see text).

Range (9 species) is the second highest documented in the Philippines, exceeded only in Kalinga Province in the northern Central Cordillera of northern Luzon, which has the largest area of high mountains of any part of the Philippines (Heaney et al., 2005a).

Relative abundance of small non-volant mammals on Kitanglad (Fig. 15) follows the pattern of gradual increase with increasing elevation that has been noted on Mt. Isarog (Luzon), but again the increase appears to be shifted to higher elevations. Interestingly, abundance on Kitanglad at 2250 m (Site 6) is higher than anywhere on Mt. Isarog, which reaches a maximum elevation of 1966 m. From this, we hypothesize that density of small mammals is positively related to the maximum elevation of the mountain (and perhaps mountain range). In other words, on very high mountains, although density at low elevations may be low, the densities at high elevation (near the peak) will be very high; and on low mountains, though density may be comparatively high at low elevation, the maximum density (near the peak) will be low. This hypothesis can be tested by conducting transect surveys of mountains of varying elevation throughout the Philippines.

Mammalian Biogeography on Mindanao

The mammals that occur on Mindanao are part of the fauna that also characterizes a set of smaller islands in the southern Philippines, including Basilan, Biliran, Bohol, Dinagat, Leyte, Samar, and smaller nearby islands. This region formed a single large island during Pleistocene periods of low sea level, reaching 120–125 m below present level on four occasions during the last 650,000 yr, the most recent about 18,000 yr ago (Bintanja et al., 2005; Heaney, 1984, 1986, 1991a, 1991b). Within this former island, referred to as Greater Mindanao, species that occur in the lowlands are widespread on most of the current islands (Heaney, 1986, 1991b, 2001; Rickart et al., 1993), but species that occur in montane and mossy forest occur only on Mindanao itself, with the exception of *Batomys salomonseni* (Heaney, 1993; Heaney & Rickart, 1990; Musser & Heaney, 1992; Rickart et al., 1993, 1998, 2002, 2003).

The mammal fauna of the Kitanglad Range is notable for including three species that are currently known from no other place (*Alionycteris paucidentata*, *Crunomys suncoides*, and *Limnomys bryophilus*). However, we suspect that their apparent restriction to the Kitanglad Range is an artifact of the very poor sampling of mammals on the other mountains of central Mindanao, and we predict that these species eventually will be found elsewhere. Most of the other montane species that occur on Kitanglad are also known from Mt. Apo, where extensive sampling has been done (e.g., Sanborn, 1952). We hypothesize that the mammal fauna of the

Central Mindanao volcanic sector (see "Geology of the Kitanglad Range," above) will prove to be generally homogeneous, and that local differences in species composition will arise from specific habitat associations of certain species (e.g., the occurrence of some bats only near caves, and some insectivores and rodents only in mossy forest) rather than local endemism. The central Mindanao region includes the area between the Agusan River and the Mindanao and Alah rivers (Fig. 2). We make this prediction based on the relative continuity of high-elevation habitat throughout this area and the relatively young age of the sector (not more than 3 million yr).

Three portions of Mindanao (the Zamboanga Peninsula, the eastern sector, and the Daguma–Sarangani sector) are much older, and coalesced into a single island not more than 5 million yr ago (see "Geology of the Kitanglad Range," above). Accordingly, we hypothesize that each of the three will be found to have endemic species of mammals, primarily at the higher elevations (where locally endemic species tend to be found throughout the Philippines). The mammals of these three portions are very poorly known. One species (*Crocidura grandis*) is currently known only from Mt. Malindang on the Zamboanga Peninsula, and it may be a high-elevation endemic of that region, though current evidence is weak. There are no publications on the mammals of either eastern Mindanao or the Daguma–Sarangani sector; clearly, future surveys in all three areas should be given high priority.

Distribution and Ecology of Non-Native Species

The impact of non-native (exotic or alien) mammals on native species is of concern because of the negative impact that they have in some areas, especially on isolated oceanic islands (Atkinson, 1989; Goodman, 1995; Meffe & Carroll, 1997). Non-native mammals, including the house shrew (*Suncus murinus*), Asian house rat (*Rattus tanezumi*, a member of the *Rattus rattus* complex), and the spiny ricefield rat (*Rattus exulans*) are abundant in disturbed habitat throughout the Philippines (Barbehenn et al., 1973). However, as we have noted previously, these species do not occur in undisturbed forest that supports a rich fauna of native rodents and insectivores, such as on Mt. Isarog and the vicinity of Mt. Bali-it, on Luzon (Heaney et al., 1999, 2005a; Rickart et al., 1991). We found the same pattern on Kitanglad; although non-native species were abundant in agricultural areas, they were absent in old-growth forest. During our entire survey, we captured only two non-natives in forest habitat: one specimen of *R. tanezumi* from along an established trail system at 1900 m (Site 5), and one specimen of *R. exulans* in regenerating forest (Site 15, 1450 m; Table 2). This situation differs from that on the species-poor islands of Negros and Camiguin, where *S. murinus*, *R. exulans*, and, often, *R. tanezumi* are abundant in mature forest (Heaney et al, 1989, 2006). This supports the hypothesis that "the number of species in the native community of small mammals determines the success of non-native small mammals in invading native habitat on oceanic islands" (Heaney et al., 1999; see also Kennedy et al., 2002). Further tests of this hypothesis on islands of varying size and species richness, and in forest patches of varying sizes and disturbance history, would be of great value for conservation managers.

Conservation and Management of the Kitanglad Mammal Fauna

As late as about 1870, Mindanao was almost entirely covered by rain forest of several types, with significant cleared areas only in a few coastal areas (Fig. 16; Anonymous, 1876). Although large areas were certainly a mosaic of slash-and-burn garden patches, second growth, and forest of various secondary stages, this was a far larger extent of rain forest than on Luzon, the other large island in the Philippines (e.g., Heaney et al., 1999). By 1903, the extent of large cleared areas had expanded to perhaps 10% of the island (Anonymous, 1905), and by 1963 to about half of the island (Huke, 1963). By 1987, most of the lowland rain forest had been destroyed, though extensive tracts of montane and mossy forest remained (Fig. 16; National Mapping and Resource Information Authority, 1988). Further loss of the little remaining lowland forest continued to 2000 as the patches of old-growth forest declined in area and in number, so that the only extensive old-growth forest that now remains on Mindanao is montane and mossy rain forest (Environmental Science for Social Change, 2000). The Kitanglad Range, the other high ranges of central Mindanao, and the mountains of eastern Mindanao

Conclusions

The Kitanglad Range clearly has one of the richest mammal faunas in the Philippines. The volcanic soil and abundant rainfall promote high productivity. The height of the mountain and the large area above 1000 m combine to produce several diverse habitats, each of which has its own distinctive set of mammal species. Our data show that bats are most diverse in the lowland areas, whereas non-volant small mammals are most diverse at the high elevations, probably peaking in species richness near the transition from montane to mossy forest. Species that occur in the lowlands tend to be widespread within the Philippines (with a few exceptions that are more narrowly distributed), whereas most species living at high elevations are endemic to the mountains of Mindanao. Some of the endemics may be restricted to the central Mindanao volcanic sector, or, in the case of three species, perhaps only to Kitanglad.

Although the Kitanglad Range is under continuing threat from habitat destruction, many of the native species appear able to tolerate at least some habitat disturbance. Non-native species that destroy crops in agricultural areas are unable to penetrate into old-growth forest, probably because of the presence of the rich native mammal fauna.

Clearly, if Mt. Kitanglad Nature Park is to succeed as a biological preserve, each of the major forest habitat types must be successfully protected, along with specialized habitats such as caves. Lowland forest has been most seriously damaged, and it is the habitat most in need of protection and restoration. Over-hunting has badly depleted many species of large mammals, including large bats, and must be greatly reduced.

The Kitanglad Range serves as the headwaters of many of the major rivers of northern Mindanao (Environmental Science for Social Change, 2000), including the Cagayan, Tagaloan, and Pulangi rivers. Protection of the forest on Kitanglad will not only help to sustain the wonderful mammal fauna that we were privileged to study, but it will also serve the interests of the people of northern Mindanao, who require protection from flooding and drought, and access to clean, abundant water for many essential purposes, as well as access to forest products, and who rely on the forest as an integral part of sustaining their cultural heritage. Conservation is essential not only to sustain the marvelous Philippine wildlife, but also for the economic and social well-being of all people of the Philippines.

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